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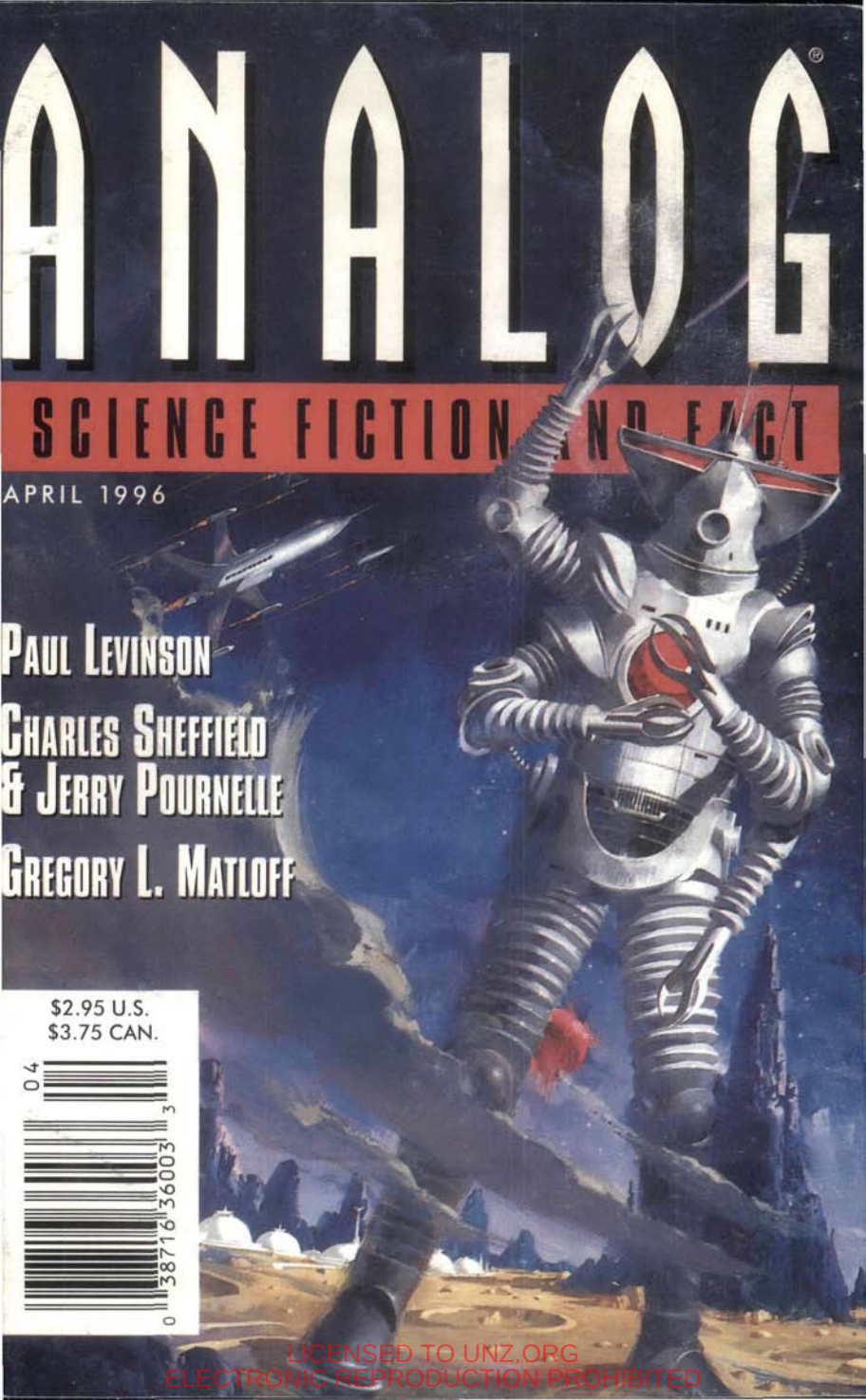

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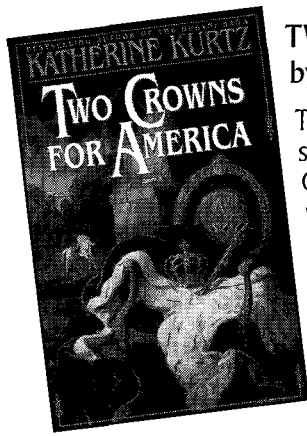

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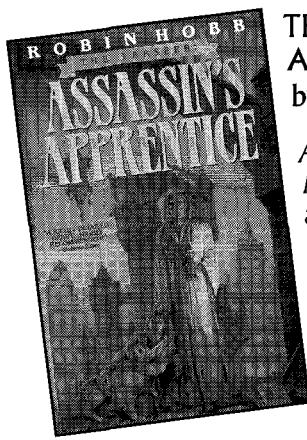

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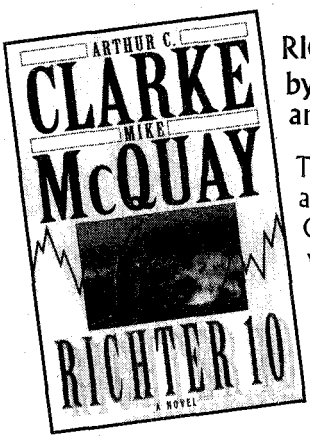

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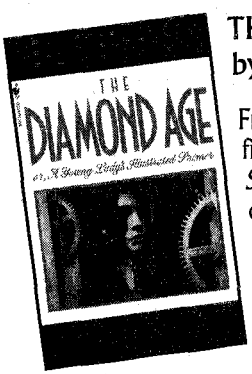

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April 1996

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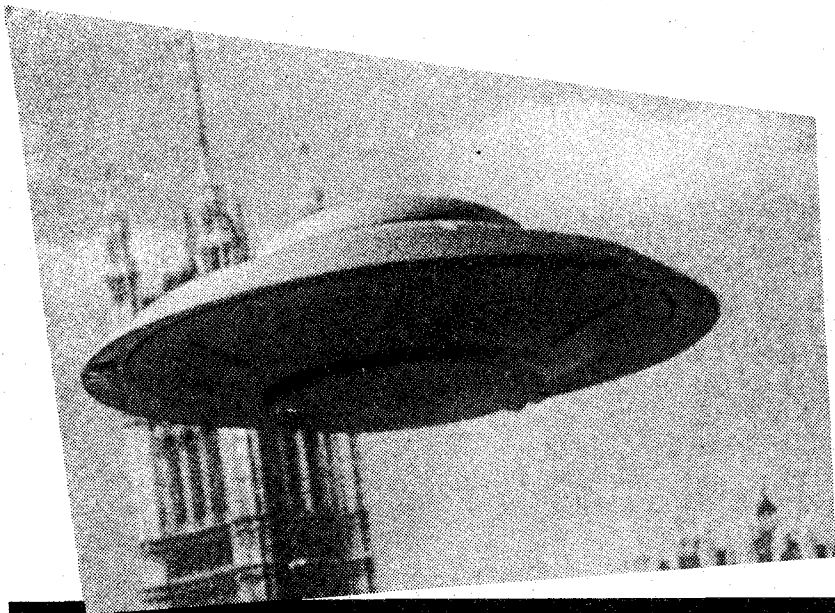

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GUEST EDITORIAL Kelvin Throop

WHY WE MUST GO TO THE STARS

Yeah, I know—just because it's poor old Kelvin, and I've been known to make the occasional snide remark about some nefarious nitwit, you're sitting there assuming I'm about to lash out with ridicule at some innocent new victim.

Nothing could be further from the truth. Actually, I'm about to make amends.

I admit I have sometimes been a bit annoyed with some of the people who campaign against things like nuclear power plants and space travel. Often (not *always,* of course) they're the same people. Space travel, they tell us, costs far too much and does nothing for people on Earth. (I suppose they think shiploads of hundred-dollar bills are being rocketed into space.) At least, they say, let's solve our problems on Earth before we mess around Out There.

Nuclear reactors, of course, are too dangerous. *Of course* their supporters claim an accident is extremely unlikely. What else *could* they claim? But even if they're right, say the opponents, if an accident ever *does* happen, it might be so destructive that we dare not run even the slightest risk of it.

At times I've been tempted to point out that that's much the same rationale used by some to justify their fear of flying, demonstrably the safest form of transportation yet developed. At other times I've been struck by the irony of these same people's ignoring the ever-present danger of meteor strikes, something that we *know* happens periodically and can have far more serious consequences than any nuclear plant mishap.

But *now* I've put all that behind me. I've decided that they're *right* on the issues at hand—or at least one of them. As you'll soon see, they can't be right about both.

Obviously we *should* solve our problems on Earth, and obviously the danger of nuclear reactors misbehaving is one of those. Obviously we shouldn't build any more, and we should make sure that infallible evacuation plans are in place for everyone living anywhere near plants that are already built and, for whatever stupid bureaucratic and economic reasons, can't be shut down right away.

But that's the least of our worries. What everybody seems to overlook is that we *all* live near a far larger and more dangerous nuclear reactor than

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any on Earth. I refer, of course, to the Sun.

True, it has a pretty good safety record so far; and theoretical projections say it's even less likely to fail catastrophically than a well-designed human-built power plant. But if it ever *did* explode, or something equally unpleasant, it could do an *enormous* amount of damage. It could literally wipe out *everything* on Earth!

And just how reliable *are* those theoretical assurances that it won't happen? Theorists have often changed their minds. . . .

Obviously, such an enormous and unpredictable nuclear reactor so close at hand is a clear and present danger to all of us. Just as obviously, we're not at present in a position to remove the threat by decommissioning and dismantling it. Therefore we need an evacuation plan. Anyone truly concerned about Human Safety should be working posthaste to develop means to get all of us away from the Sun as quickly as possible!

Unfortunately, that means Space Travel—and on a rather grand scale, at that. Hence my most regretful assertion that those who oppose both nearby nuclear reactors and space travel can't have it both ways. The proximity of such an enormous nuclear reactor as the Sun—without so much as an emergency override in competent human hands, yet!—is a life-and-death problem to everyone on Earth. And the only way to solve it lies in spaceflight.

Not the kind of piddling little spaceflight we've dabbled in so far; if that Big Reactor in the Sky went really haywire, no place in the Solar System would be safe. We'd have to get far away—at least as far as the nearest other stars, several light-years away.

Of course, we wouldn't want to get too attached to other stars, either. They're *all* thermonuclear reactors, and therefore pose the same danger as the Sun. So eventually we'll have to learn how to live without a star nearby to provide energy. That's a mite awkward, since everything about life depends on energy; but we'll cross that bridge when we come to it. Our *first* consideration has to be Safety. After we figure that out, then we can think about the rest.

Of course—and I hate to be the bearer of still more gloom, but I feel I really must point this out—even getting away from the stars will not be a final, ultimate, Solution to End All Solutions. You think a star uses a lot of

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POSTMASTER: Send change of address to: ANALOG SCIENCE FICTION AND FACT
P.O. Box 5133, Harlan, IA 51593-5133.
IN CANADA RETURN TO: 3255 WYANDOTTE STREET EAST, WINDSOR, ONT. CANADA N8Y 1E9
Editorial and Advertising: Analog Science Fiction and Fact, 1540 Broadway, New York NY 10036
Subscriptions: Analog Science Fiction and Fact, P.O. Box 5133, Harlan, IA 51593-5133 ISSN 1059-2113
Printed in the U.S.A.

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energy? Think about a whole *galaxy* of them! And yes, Virginia, there *are* sometimes galactic-scale explosions. . . .

So, obviously, to be really safe, we must eventually learn to move into *intergalactic* space. Right?

Well, Rome wasn't built in a day, and I could hardly expect an intergalactic transport system capable of moving whole planets full of people to spring into being overnight. We'll have to build up to it gradually—but the longest journey begins with a single step. And if you don't take that step, the journey doesn't happen.

Of course, somewhere along the line we'll have to come face-to-face with the fact that any system capable of rescuing us from a powerful and potentially dangerous energy source will itself have to *use* a powerful and potentially dangerous energy source. We can wait until somewhere far down the road to think about that, too—or we can try to come to grips with it, and its implications, now.

In any case, the important thing is that we're *already* living dangerously close to a far more powerful nuclear reactor than any of the toys built by man on this planet. We need an evacuation system to ensure absolute human safety forever and ever. That will require space travel capabilities on an ever larger scale—which, of course, we'll have to design and build so that *they* are absolutely safe.

Obviously, our work is cut out for us. There's a *lot* to be done, and no time to waste.

We'd better get cracking! ■

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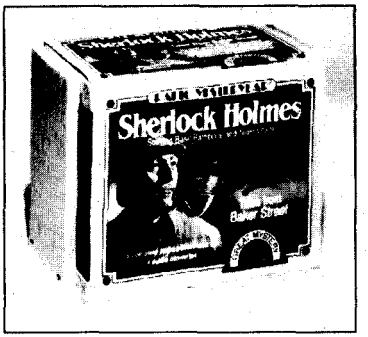

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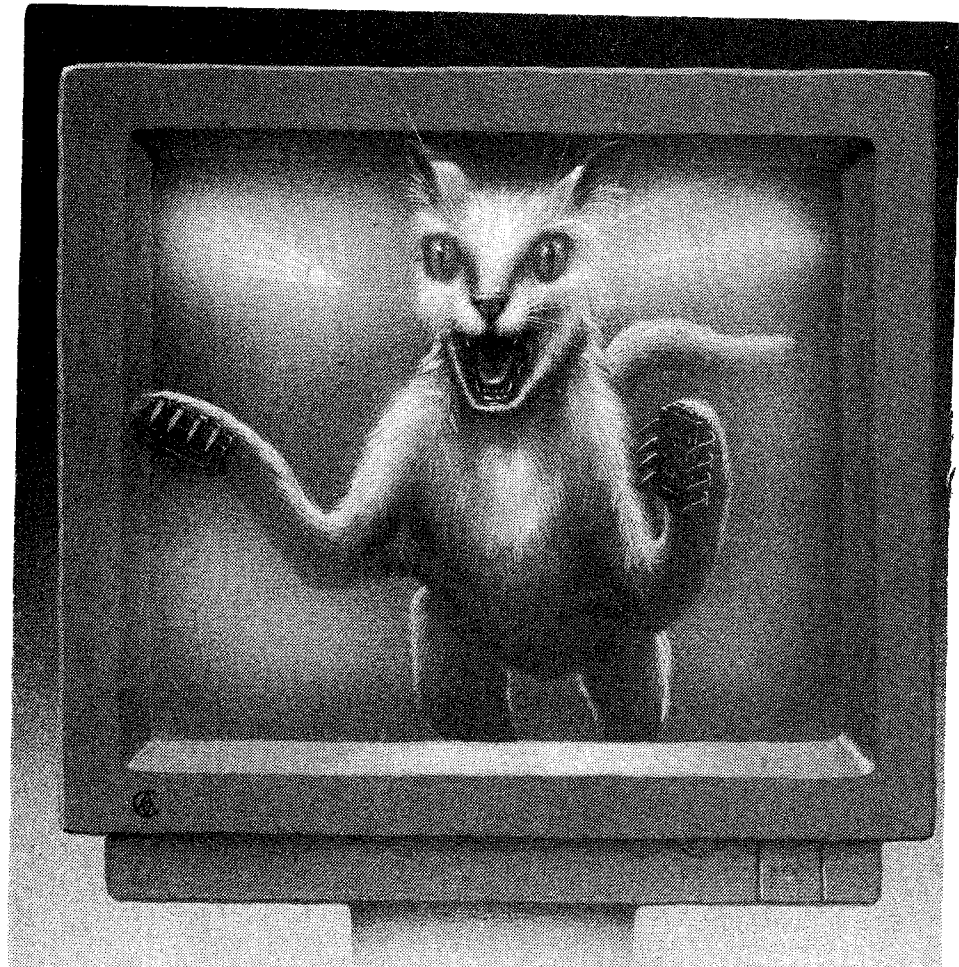

Brian C. Coad

CAT, MOUSE

A little fable for the season. . . .

Illustration by Alan M. Clark

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Three decades back, an Eastern girl who called herself Autumn Leaf, blew West. She crashed in a hippie pad with Mister Richguy.

Mister Richguy was good to her. She became his old lady. Together, they went into the pot business.

Soon they had beaucoup spare change.

Their phone bills were awful high. They invested spare change in college courses and learned how to build an electronic thing to route calls so they did not have to pay the phone company.

That was the, so to speak, embryo of the AI that later became the Ghost Cat.

Their business got too big to carry in their heads. They invested in computer courses and upgraded the AI. It developed into a Ghost Cat fetus, and soon had their business running smoothly. They got it into hacking.

Programmed by Autumn Leaf and Mister Richguy, the AI worked out ways to transfer, without getting caught, electronic cash floating around from banks and such, into their own account. This was safer than selling pot, which they quit doing. The AI became a Ghost Cat kitten.

Autumn Leaf and Mister Richguy learned all about financial networks and international finance. They programmed their AI to surf, or, more accurately, to prowl, the networks. Semi-autonomous, it was instructed to look for, say, a coming devaluation of the Polish zloty (or Paraguayan guarani), or, say, based on the price of tin, to anticipate a fall (rise) in the Bolivian stock market. It prowled with a big wad of electronic cash, which it could invest in such events, and make a profit. It was soon maturing into a full-grown Ghost Cat.

When Autumn Leaf and Mister Richguy owned several million dollars, they got bored. By then, all the business they did was legal and risk free, and the zest had gone out of it. Making money had become nothing more than a game of pushing counters around. They turned all that stuff over to the AI. The only constraint they put on it was to forbid it to do anything illegal except in a dire emergency.

The AI was now a full-grown Ghost Cat but for one thing: it had no body to download into when it was not working. It could not get out of its owners' equipment, and cyberspace.

Long past hippie times, Autumn Leaf was still into feelings, growth, human potential, and such. With time to spare, she thought long and hard about their AI. She decided its growth would be stunted, it could never achieve its full potential, unless it had somewhere to get out of the nets, roam around freely, smell the roses, and sense the power of flowers.

She designed a cat's body for the AI to download into, and persuaded Mister Richguy to help her build it. It had pure white fur. She programmed a lot of humanness into it.

She did not give it a name.

Autumn Leaf and Mister Richguy lived in a big house on a hill overlooking the ocean. Below was another house. A Mother Lady came to live

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there, with a dozen children. In its cat's body, the AI observed their arrival. Cautiously it investigated them. When it had decided they were not dangerous, it decided to visit the Mother Lady.

In the side door of the Mother Lady's house, there was a small flap cut, for cats to come and go. Her children were in the garden. The AI/cat crept up to the flap in the side door. It went inside, and searched for the Mother Lady.

It found her in the kitchen, peeling apples for a pie. Purring quietly, it went close and rubbed against her legs. She picked it up, stroked it. "Where you from, you beautiful puss?" she said. "I call you Ghost Cat, 'cos you suddenly appear out of nowhere."

That was how he got his name. Once he had a name, he never thought of himself as "it" any more, only as "he."

He could not tell the Mother Lady where he was from. He was not equipped for speech. She took him out to the garden and introduced him to the children. Soon, the pleasantest, most relaxing thing he ever did was to sit on her patio in the sunshine, watching the children at play.

The Mother Lady put a padded basket for him to sit in on the patio.

On a prowl of the nets, the Ghost Cat collected his month's tax liability, a routine chore. That month he had done a lot of business. There was a great deal of money owed to the IRS.

He ran hard copy of the tax liability. Mister Richguy examined it. He usually had the same attitude to taxes as to other counters, but this time the amount due was so enormous, he became quite angry. "Your damn animal has screwed up," he told Autumn Leaf, at the same launching a kick at the Ghost Cat.

Fortunately the Ghost Cat, who was plugged into the nets by paws, tail, nose, and ears, saw the kick coming, managed to release himself, and was on Autumn Leaf's lap before it landed where he had been.

Autumn Leaf's lap was safe but uncomfortable. Even so long after the Summer of Love, she was still into beads and macrame, which dug into him and abraded his fur.

Autumn Leaf chucked him under the chin. "What's, like, the trouble?" she asked Mister Richguy.

"The damn cat's in cahoots with the IRS to rob us blind," said Mister Richguy.

"That's not so, is it, puss?" She stroked the Ghost Cat. "Besides, it don't matter anyway. Money's only, like, counters."

"Sure, sure," said Mister Richguy, "but I still hate to see any more than has to be sent off to Washington to support politicians. Cat can't do better, he's in for reprogramming, or maybe getting his neck wrung."

Autumn Leaf touched her lips to the Ghost Cat. "Maybe you better, like, stay out of the Old Man's way for a while," she said. She carried him to the front door, opened it, and put him outside.

Tail swishing, fur fluffed out, he trudged down the hill to the Mother Lady's place.

He found the Mother Lady in her

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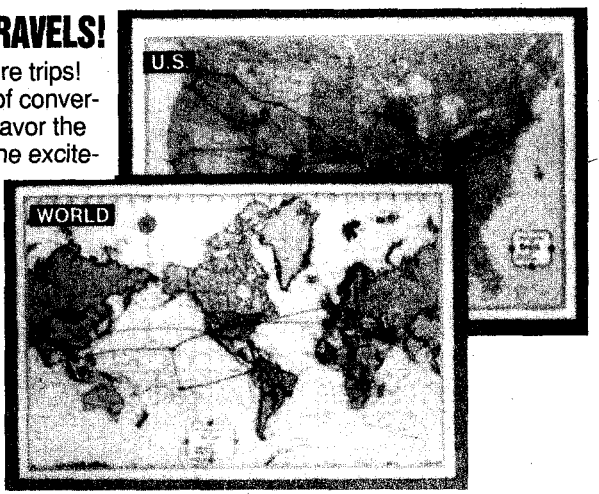

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rocker on the patio, watching the children in the garden. She sensed his mood immediately. "You in some tantrum, you old Ghost Cat," she said, the moment she saw him.

The Ghost Cat poked his tail straight up and strutted about the patio to show her how right she was.

"Easy, easy," said the Mother Lady. "Why you not sit in you basket, watch the children? You feel better."

The Ghost Cat flashed his eyes at the Mother Lady. In the background he could hear the children's voices, shrill and silvery in the Sun-drenched air. She tapped on his basket and made the curious noises with which she sometimes invited his obedience. He eyed her again, then slowly climbed into the basket. "Who you mad at, anyway?" the Mother Lady asked.

If he could have spoken, he would have said the accursed tax man, the tax laws, and my Master in the house on the hill. As he could not speak, he had to be content with a growl.

The Mother Lady's attention wandered away from him, down the garden to the children, beyond them, and out over the ocean. Out there, a great ship puffed towards the horizon.

The Ghost Cat felt ignored. He checked the children.

The Mother Lady's children were waifs and strays. Whenever she ran across a waifed or strayed child, she brought it home. Just then, there were six boys and six girls.

At the bottom of the garden, where the early morning dew had converted freshly turned soil into thick mud, the boys—two each, white, black, and Asian—were studying its properties. The Ghost Cat, beginning to settle down, marveled at the way they studied the properties of things, and learned about them.

The girls, nearer him on the lawn, were playing ballerina. Music was provided by the Vietnamese girl, who owned a flute. The rest teetered and tottered on tiptoe around her. They giggled a lot.

Bees buzzed in the blossoming hedge of forsythia along one side of the garden. Gradually the Ghost Cat's growl dissolved into a purr.

He blinked drowsily in the sunshine.

Daniel, the taller black boy, scooped up a handful of mud and kneaded it. The Ghost Cat guessed he planned a controlled experiment, throwing it at another boy to observe how it splattered.

Something wriggled in Daniel's mud. He stopped kneading to see what it was. It was a long, pink worm. He liberated it from the mud and held it high, like a trophy, stretched between two hands. The other boys crowded around to see it.

Now, thought the Ghost Cat, having studied the properties of mud, they will go on to study the properties of worms.

"Ain't never in all the world been a worm big as this one," said Daniel.

" 'S only a baby compared to what my aunt has back in Iowa," said the fair-haired white boy.

"Maybe a baby, but he scare the pants off of you!" Daniel shoved the worm in the fair boy's face. The boy dodged away. So did Daniel's next vic-

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tim, the little Cambodian.

Daniel chased the others all over the garden, but failed to catch any of them.

The Ghost Cat watched and purred louder.

Daniel went after the girls. They quit being ballerinas, screamed, and scattered.

"Stop you teasing, Daniel," yelled the Mother Lady. "You put that worm right back in the earth where he belong!"

Daniel shuffled a bit on the lawn, then returned to the muddy place and put the worm on the damp earth. With the other boys, he watched it wriggle out of sight.

The Vietnamese girl smoothed her dress. She put the flute to her lips again, and resumed playing.

The other girls resumed their toe-tip teeter totters. They giggled some more.

In a little while, the Mother Lady grew restless. She kept looking at her watch. Presently she stood up, gazed out over the ocean. The great ship was hull down on the horizon. " 'Bye, ol' ship, goin' Singapore, Hong Kong, some such place," she said. "Wish you'd take me with you!"

She looked at her watch again, and went into the house.

The Ghost Cat went to the side door of the house and went inside too, through the little cat flap. It bothered him deeply that the Mother Lady would want to be on a ship, carried away from the children. He found her in her living room. The TV was on, some sort of current affairs thing about simplified tax laws, but he took not much notice of it. He knew more than he wanted to know about tax laws. What he did notice was that the Mother Lady's eyes were teary, and she was dabbing them with a white handkerchief.

He forced her to notice him. In body language, he asked what was troubling her.

"Taxes," she told him.

She went on mumbling to herself, "Ain't it always the same? You work like a little engine, get a house for the children, everything fine. Then big old taxman come. He say you owe, puts lien on salary, you not have money left to pay the rent." She switched off the TV. "Old program here don' tell me nothin' that help."

She picked up the Ghost Cat, held him at arm's length in front of her. "You look some fierce, old Ghost Cat. Don't do no good. Ain't nothin' you can do. Rent not paid, me and the children be gone I don' know where."

I bet there is something I can do, thought the Ghost Cat. He leapt out of her hands, over to the cat flap, through it, and straight up the hill to his own place.

In his own place, the Ghost Cat immediately plugged himself into the nets. Everybody's problem is out on the nets somewhere. He searched for the Mother Lady's.

It was soon found. The Mother Lady worked nights for the telephone company. That was how she paid her bills, fed the children, and paid rent. She had sent in her tax forms in April,

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just like everyone else. All her money went on the children, but she never kept records to itemize, so she only took standard deductions.

The tax man wrote her saying she owed three thousand dollars.

She wrote the tax man saying she had no money. She had spent it all on the children, so couldn't she be excused?

Only, wrote the tax man, if she could produce a set of books showing, item by item, what she had spent.

Can't do no such thing, she wrote back.

Well, then, said the tax man's next letter, we will have to put a lien on your salary.

He had put on the lien. The telephone company had done what they could to hold back as little money as possible, but next month, as the Mother Lady knew, her salary would be too small to cover the rent.

The Ghost Cat immediately went stalking the responsible tax man.

He was soon found. His name was Ed "Muscles" Grimond. His personnel file held many commendations for the efficiency with which he recovered delinquent taxes.

Unpleasant individual though he must be, the Ghost Cat had to meet him. He burrowed electronically into the man's computer. Looking out through its screen from inside, he saw a small individual who looked much like a mouse.

Numbers scrolled on the man's screen, and his eyes gleamed as he surveyed his day's victories over the taxpayers.

Parts of the Ghost Cat went in various directions to do background checks on Ed "Muscles" Grimond. One part came back with a school kid piece about his first day in Washington High. Another new kid, taking a hard look at him, tried to give him the name of "Mouse." Before others followed suit, Ed said, if they had to call him something, it had better be the proper Latin term, *"Mus musculus,"* not the commonplace "Mouse."

Another kid, observing his puny physique, corrupted "Mus Musculus" to "Muscles."

From there on, he was Ed "Muscles" Grimond, and all the kids had a good laugh.

Another part of the Ghost Cat came back with details filed in the computer of Ed's psychiatrist. The record said he was terrified of cats. He was also afflicted with the fantasy that, somewhere in cyberspace, there existed a blind-ended mousehole, into which, if the real world became too much for him, he could withdraw and be safe.

While the Ghost Cat absorbed this information, Ed "Muscles" frowned and stopped scrolling. He had come to the social security number of the Mother Lady. "Blasted woman," he mumbled.

Apparently the telephone company was not withholding as much money from her salary as it should have done.

The Ghost Cat angrily swished his electronic tail and thought how he hated taxes and tax men.

There was one way to show Ed what he felt.

Behind the man's computer screen,

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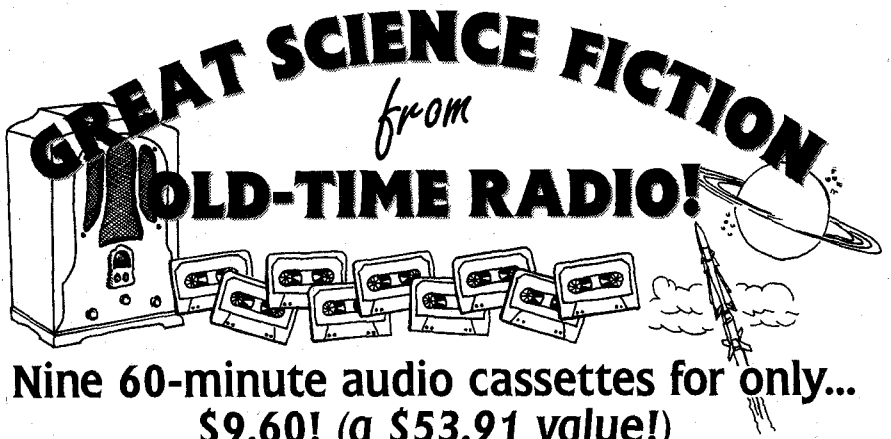

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he created a monstrous virtual cat. He had the cat leap out of the screen at the man.

Ed "Muscles" Grimond squawked loudly and withdrew into his cyberspace mousehole.

The Ghost Cat let the virtual beast sit on Ed's desk for a while, towering over his inert form as it ominously cleaned its paws.

Presently he deleted the beast.

He set off on a tour of the IRS files. Wherever he found a reference to the Mother Lady's tax problems, he deleted that.

He toured the telephone company's files.

Wherever there was any reference to the tax man's lien, he deleted that.

While he was about it, he gave the Mother Lady a raise.

He went home.

Only when he was unplugging himself did it occur to him to wonder if he had done anything illegal.

He had not, he told himself, because he could not. He was programmed absolutely not to.

Of course, there was that dire emergency clause.

Maybe this had been a dire emergency.

Anyway, he felt good, and not to worry.

He went outside and down the hill to the Mother Lady's house.

The Mother Lady was back on the patio again, rocking in the sunshine. The children were happy in the garden.

Using every ounce of body language he possessed, he assured the Mother Lady that, from here on, everything, everything, would be all right. ■

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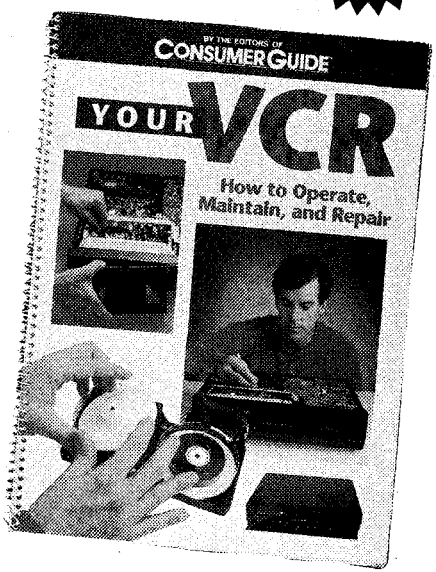

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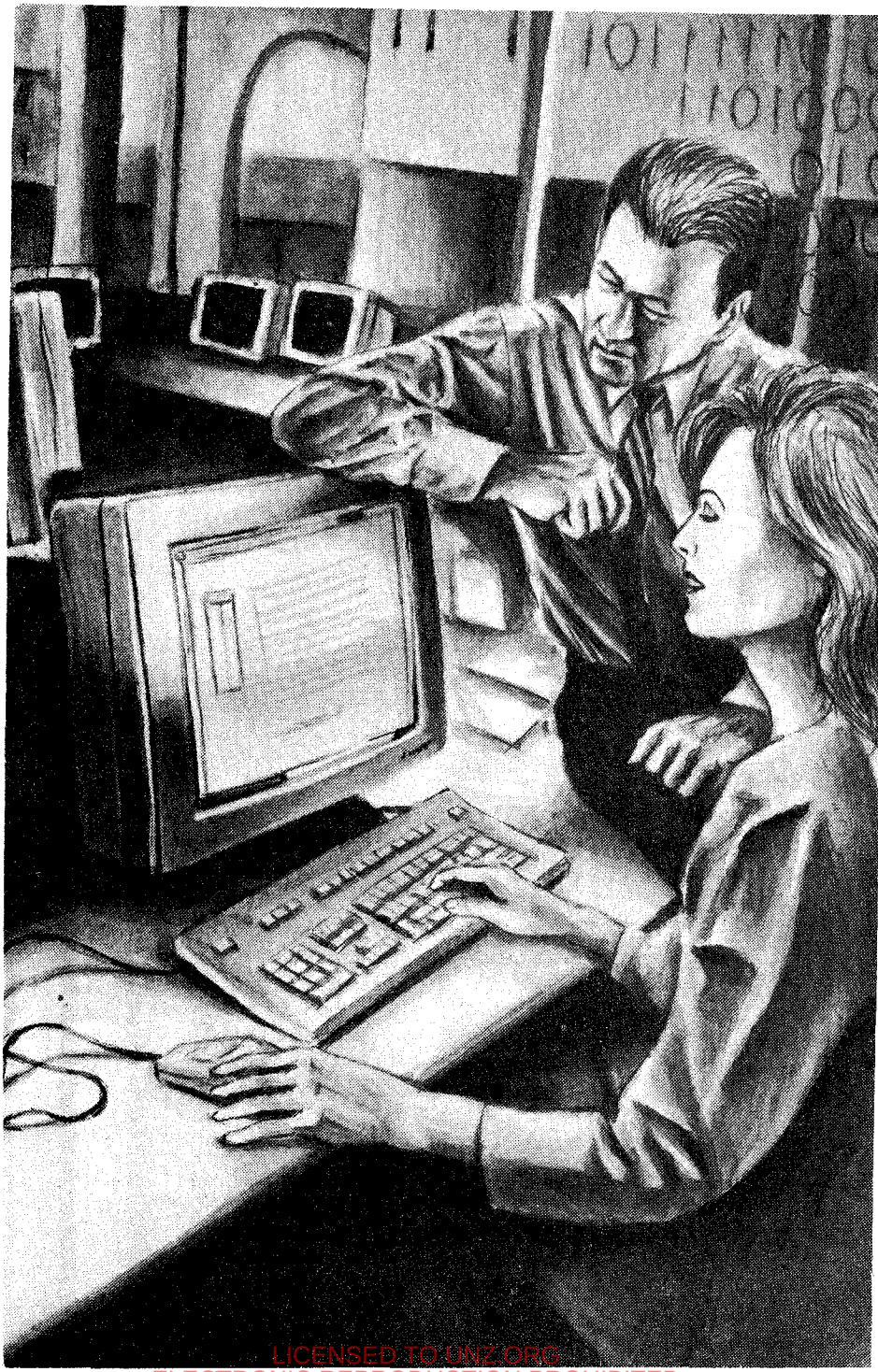

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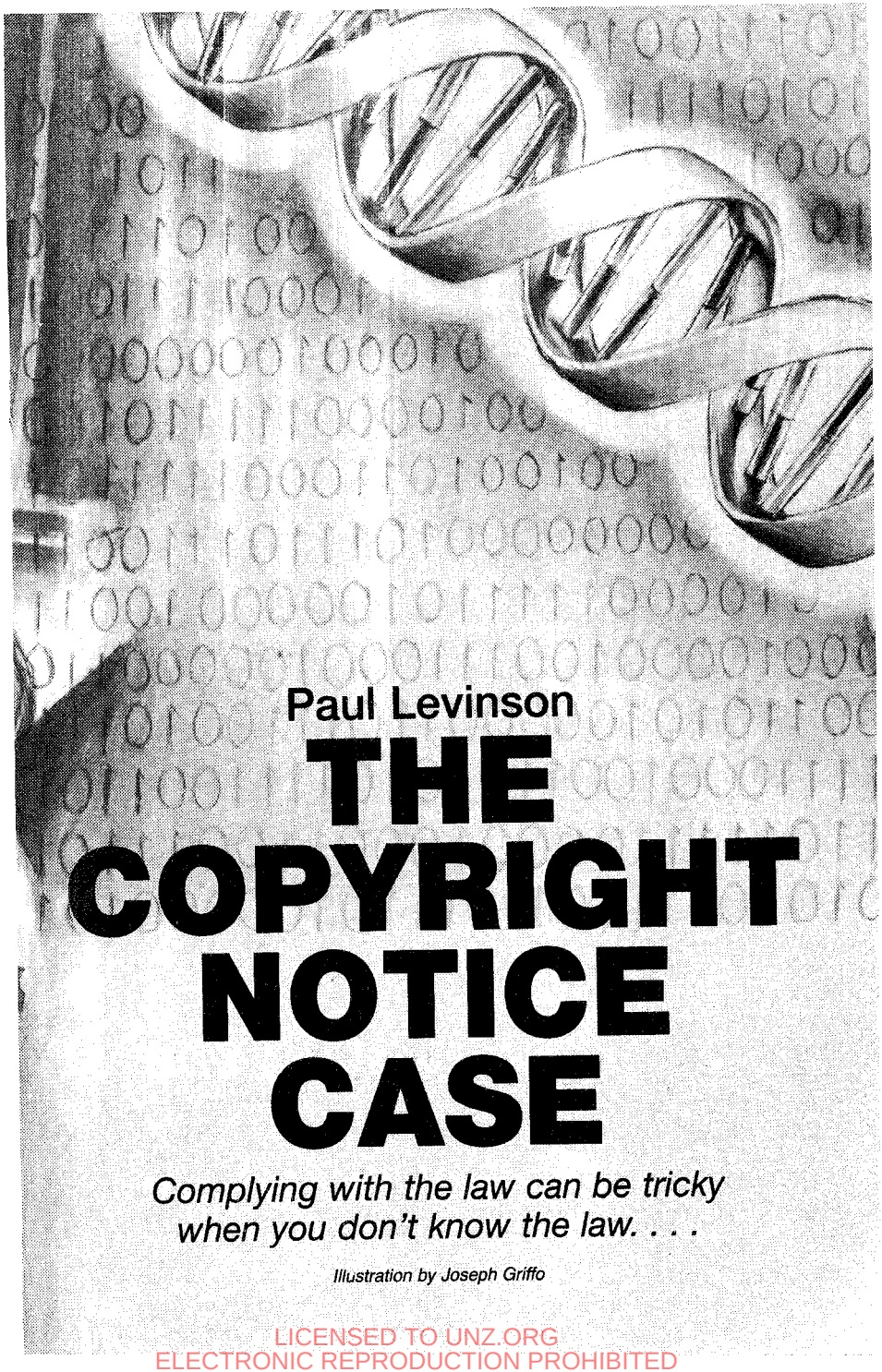

Paul Levinson

THE COPYRIGHT NOTICE CASE

Complying with the law can be tricky when you don't know the law. . . .

Illustration by Joseph Griffo

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The gust caught my umbrella the second I got out of my car, before I'd even had a chance to fully open the thing. I struggled for a bit, then gave in to the inevitable. Another inside-out dripping mess to deposit in the trash can. The wild force of nature wins again.

I turned my collar to the cold rain and hustled up the brownstone stairs. I pulled out my ID and showed it to the uniform.

"Down the hall, one flight up, second door on the right. They're waiting for you, Dr. D'Amato."

"Right," I said. I hated these long brownstone stairs—rushing up them always made me breathless these days. I guess I could've walked up slowly, but that wasn't my way.

"Phil," that was Dave Spencer, even less hair and more belly than I, bent over a body, male, looked to be in his late twenties. "Come take a look at this." Dave was the coroner. He often called me in for special consultations—came with my forensic territory.

I looked. The corpse had his eyes wide open, like he'd been shocked to death. But there were no electricity burns on the body that I could see, and in fact the nearest electrical outlet was some fifteen feet away, next to a computer on the other side of the room.

"Chemical, food allergy, lethal injection?" I rattled off the usual suspects in cases like this. And of course there was the unstated omnipresent social tetrad of choices: death by natural causes, accident, suicide, or murder.

"Not likely," Dave shook his head. "No obvious puncture marks. No discoloration of the lips. We'll know more after the full test course."

"So what's your best guess?" I asked.

"I have none," Dave said. "That's why I asked you in. It's like something reached in and turned up the juice in this guy's nervous system. Turned up the volume to lethal levels. Looks like heart attack and ten other things gone wrong here—never seen anything like it."

"All right," I said. "I'll have a look around." For some reason, I had a reputation in the department as the forensic scientist to call in when something inexplicable seemed to have happened. Well, I knew the reason—I'd been involved in my fair share of weirdo cases in my time, some of them public. And my popular writings in fields ranging from physics to genetics were pretty well known. "This guy have a name?"

"Glen Chaleff," Dave replied. "Some kind of computer programmer."

Chaleff's apartment was nothing out of the ordinary. Bland furniture arranged unsurprisingly around off-white painted walls. The computer was the only thing that caught my eye. It was a sophisticated machine, lean and very powerful, it seemed to me, something well beyond the latest commercial chip. The screen had two words on it.

"Copyright Notice"

I put on my gloves before touching the keyboard—never mind the standard precaution of not doing anything to disturb possible fingerprints and evidence, I was thinking more about not getting electrocuted on the out-

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side chance that's what had happened to Chaleff. I pressed the up and down arrow keys to see if there was any other text above or below on the screen.

Nada. Just a bunch of hash above, three-quarters faded to nothing, like I had come in on the end game of some kind of program that self-destructed after use. I arrowed back to "Copyright Notice."

It was fading away now, too.

Jenna Katen was the girlfriend. There's almost always a girlfriend in these sorts of cases. Lieutenant in charge asked me if I wanted to come in and interview her. She was the reason Chaleff was considered a possible homicide.

"She discovered the body, she says he was working on some kind of genetic project that seems on cloud nine to me; I thought you might have a better chance of understanding what she's talking about. You're a real hound for that stuff, right?" That was the lieutenant's briefing.

"Right." I said.

Jenna was really striking. Looked a lot better than girlfriends of the deceased usually do, except on television. Soft green eyes and soft brown hair falling around her shoulders just the way I like it. Keep your mind on business, D'Amato.

I could see she'd been crying. "You look too smart for me to offer you a smoke," I said. "How about some caffeine?"

"Sure," she looked up.

"Hot or cold?"

"Diet soda would be nice."

I went outside and coaxed a can from the machine.

"Why don't you tell me your story from the beginning," I said, trying to pour the soda into a cup so that it didn't fizz over the top. Never worked. "Pretend I'm an ignoramus about the science—but tell me everything, and spell it out as much as you can."

She sipped the soda and squeezed the cup. "Glen was working on a special facet of the human genome project."

I nodded. "The one that hopes to eventually identify and map the function of every protein compound—every gene—on human chromosomes."

"That's right," she said. "Except there are actually a whole bunch of interrelated human genome projects. And this is a special section of a special project. Early on—about two years ago—the main team discovered some odd material at the far edge on some X chromosomes."

"On all female chromosomes?" I asked.

"No, the material has so far been seen on only about 8 percent of the X chromosomes studied."

"OK," I said. "And what do the researchers think this odd gene is responsible for?" I knew that that area of the X chromosome was home to at least one interesting human protein—the so-called gay gene, still under intense investigation.

"Well, that's part of what makes this so unusual," Jenna said. "The material's not really a gene, and doesn't seem responsible for any behavioral or expressive trait."

"I'm not following you," I said. This is likely where the lieutenant had lost comprehension.

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"Well, the material's genetic—it's some sort of protein code—but it's not really a gene. Only 5 percent of the DNA in our genome actually goes into genes. The rest is sometimes called 'junk DNA,' and I guess you could say our little corner of the genome project has been prospecting for an unlikely fortune of information in that junk pile. You know, more clues as to how the human genome works as a whole—how proteins outside of the genes themselves prime them for operation, act as regulating enzymes, that sort of thing."

"OK," I said. "And how did Glen fit in?"

"Well, we've—Glen's—been trying to, well, read the code on that odd genetic material."

"Come again?"

"The code seems amenable to some sort of binary transformation—you know, a mapping that would translate the connections inside the protein complex into a series of yes and nos, or ons and offs. Genes themselves operate on a four-part code—adenine binding to thymine, cytosine to guanine. They're nucleotide bases, you know—A and C on one side of the helix zipper connecting to T and G on the other. I'm sorry, I'm getting too technical for you—"

"Not at all," I said, though I could've lived without her reciting the specific names of the nucleotide bases. This was basic textbook stuff for DNA fingerprinting. "Please continue."

"Well, like I was saying, the special material that Glen was working on actually has slightly different forms of the nucleotides that make them more like a binary than a four-part system."

"And—" I prompted.

"And, well, the hope, the goal, was that if we could get a reliable transformation of that genetic code, whatever it was, into binary, then we could take that binary rendering and in turn convert it into words on a screen."

"Read the genetic code, literally?" I asked.

"Well, again, yes and no. Not really the genetic code in our genes proper, but this code in a tiny part of the other 95 percent of our DNA on the X chromosome," Jenna said.

"I see," I said, though I didn't yet, at least not fully. "And Glen's death?"

"He phoned to tell me he had completed the final translation of the code, had words up on his screen. . . and when I came over, he was dead," she started sobbing. "I think those words killed him."

"OK," I poured more soda in her cup. So now I knew something: either she had killed her boyfriend, and cooked up this story to throw us off track, or there was something genuinely strange going on here. The coroner's extensive autopsy had already found no demonstrable cause for the sudden massive failure of all of Chaleff's systems that had killed him—"looks like everything just blew at once for no apparent reason," Dave told me—so we knew Chaleff hadn't just died of your common heart attack or stroke while he was doing his research. It was something more. Like something had reached in and turned off—or on—some master switch, as Dave had said yesterday. The question

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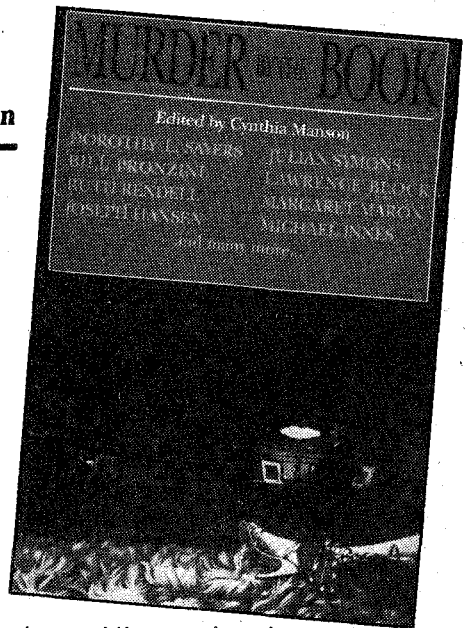
Death Between the Covers

MURDER BY THE BOOK

Edited by Cynthia Manson



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was who—and what. And the what was not only what reached in, but what was the switch?

I could see why the lieutenant was thinking homicide. In cases like this—cases involving dead young bodies—the cause of death was all too often murder. Barring tragedies like AIDS, young bodies don't very often expire on their own.

Now it might shock the public to hear this, but in many ways murder is the forensic scientist's best friend. Once the cops get a confession of murder, however inarticulate, it points to the facts, and we can use it, working backwards, to piece together a detailed description of the death and its circumstances. Reverse engineering is always easier than working from the ground up.

But truthfully, I hated confessed murder as the cause of death, always resisted it as the explanation until impossible to do so. Not only for the obvious moral reasons—I'm as glad as the next guy to find a bit less depravity in the human species wherever I can—but because, well, I savor the thrill of an investigation in which I don't know the final conclusion beforehand, in which science leads to the cause of death rather than vice versa.

And I'd learned the hard way that some kind of nefarious intervention, something worse than mere murder, always loomed as a possibility when research scientists were involved. I'm not talking about dressing up a lover's quarrel or cutthroat professional competition with a fatal malfunction in a laboratory like they do in the movies. I've had experience with things much worse. The public had no idea.

But what was the agent of death here?

Words on a screen?

They made sense neither as a weapon nor a lethally malfunctioning piece of equipment.

"You have any idea what those words were?" I asked.

She looked up at me and her eyes refocused, as if my voice had pulled her away from some contemplation deep and distant. "No," she said. "The screen was blank when I arrived."

So now I knew she was probably lying about at least one thing.

Some of her facts were easy to verify. Jenna had been telling the truth about Chaleff's last call to her apartment. And there was no sign of anyone entering Chaleff's apartment between the time of that call, and the time Jenna arrived, about forty-five minutes later, when she said she'd found Chaleff dead.

Her story about the special section of the human genome project took more work to confirm. She'd told me the MIT Media Lab had a piece of the research action. Nic Negroponte, head of the lab, was an old friend of mine. He didn't know much about that part of the project, but put me in touch with an associate who did.

"Ralph Hertzberg here," the voice on the phone said. "Nic told me to expect your call."

"Great," I said. "Let me start by trying to explain to you what I think you're working on—what I understand and what I don't—and you tell

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me where I'm wrong."

"Shoot."

"OK," I said. "DNA is commonly said to be a genetic language, but that's not quite right. It's really a recipe for the construction of other proteins into cells that have specific properties—heart cells, brain cells, and so forth in humans—cells and organs and systems that come into being during gestation."

"That's right," Hertzberg said.

"OK," I said. "So in fact, DNA isn't really a language at all—it's really an arrangement of proteins that causes other proteins to develop in a certain way, into heart cells, etc. So really DNA is a catalyst for the development of living organisms. But we say as a shorthand that it's a code or a set of instructions. Am I on the right track here?"

"Very much so."

"Good," I said. "All right, then. So tell me this: How do we get from DNA, which isn't really a language—or is only a language in a metaphoric sense—how do we get from that to this chromosomal material which Jenna Katen says Glen Chaleff was able to read on his screen?"

Hertzberg sighed. "Not very easily, but I'll try to explain. First, you have to understand that there's lots of protein material associated with chromosomes that we have no idea what the function is. Not everything there is just genes. In fact, most isn't. Some material we've identified as seeming to have a catalyst function for the genes themselves—sort of meta-catalysts—some seem to control timing of genetic instruction of other proteins in ways we're just beginning to fathom. But most of this extra genetic material is still a mystery to us."

Right, the so-called junk DNA, I thought. "And the, uh, the linguistic material on the 8 percent of X chromosomes is, was, in the mystery area?"

"Yes."

"Has this material been found only on human chromosomes?"

"So far, yes," Hertzberg said. "Primate chromosomes were the first other place we looked—chimp and ape DNA is 99 percent the same as human—and we found nothing like it."

"Nothing that could generate words on a screen?"

"Look, let me be honest with you," Hertzberg said. "I know what Jenna told you, but we don't even know for sure that this binary chromosomal material can be converted into readable words. It seems transformable into a binary code, yes, but we have no way of really testing the accuracy of that transformation, since we have nothing precisely of this kind to measure it against. And we certainly don't know for sure if that code can support actual words. What we get from that code at first is some sort of general proto-language, strongly resembling Indo-European in its subject-predicate structure, and therefore recognizable as a real language to some researchers, I guess. And assuming that to be Indo-European, or proto-Indo-European, we can make rough translations into English, Sanskrit, what have you. But the results are extraordinarily speculative to say the least—I'd say the noise to signal ratio must be well over 40

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percent in the final translation. Though that's conjecture too—the actual distortion could be far more, or less, for that matter. Bottom line: We're dealing with a hell of a lot of conjecture here. That's why we haven't published anything about this yet. It's still in the very early stages of research. Most of our work is."

"All right," I said. "Let's back up a little—I'm very much a layman when it comes to linguistics. What made you think in the first place that the binary transformation of chromosomal code yielded patterns that looked like Indo-European?"

"Ah," Hertzberg said. "That was the relatively easy part. We already have ASCII table renderings of most known human languages, including many long extinct. ASCII and binary configurations are readily transformable into one another. So when we converted the binary chromosomal code to ASCII, its similarity to primal Indo-European in ASCII was noticed right away."

"Yet you don't sound very optimistic." I appreciated the value of a research leader willing to pull in the reins on the wildest fantasies of the team, though personally I preferred someone who jumped on the lead horse and urged it to fly even farther.

Hertzberg grunted. "It's the monkeys on a typewriter typing Shakespeare problem. Or maybe sticking a duck's feet in a can of wet red paint, and having it walk across an empty canvas, is a better example. Is that art? It looks like art. But we can't accept it as art, because we know its resemblance to art is just a coincidence. Same with the chromosome code—the fact that it looks like an Indo-European language doesn't mean it is. Sometimes the reason that two words in very distant languages look like each other is just coincidence. If I were pushed for an assessment at this point, I'd have to say that that's what we're dealing with here."

I, on the other hand, was never a big fan of coincidence. It often was a shorthand gloss, a convenient cover, for significant connections we didn't yet understand. "But if it isn't?"

"Look," Hertzberg sounded like his patience was beginning to wear. "Mapping the genome is much more drudgery than the public imagines it to be. We make a connection here, trace a sequence there, but discovering what each of 300 billion nucleotides can do is a massive undertaking. So we look for relationships, for patterns of expression in the proteins. But even that is slow, slow work. Most of the breaks come from the other direction—not in studying how genes express themselves, but in anchoring an already-known expression, like an illness or a maybe a behavioral pattern, to a genetic combination. Like cystic fibrosis, or depression among some of the Amish. And the DNA outside of the genes is doubly harder to understand, because *its* connection to the phenotype is even more removed—we've got no known illnesses to tag them to."

"Right, no confessed murders to work backwards from," I said.

"What?"

"Just thinking out loud," I said, "Tell me more about the words on the

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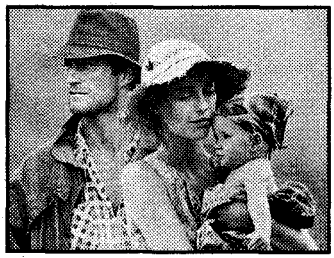

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screen. What'd they say?"

"Well, so far, Klein's the only one who's claimed to have actually produced them on the screen. Chaleff was a good worker, but no genius, and if you want my appraisal I'd say he was exaggerating when he told Jenna—"

"Klein? Who's Klein?" I asked.

"Manny Klein—Emmanuel Klein," Hertzberg replied. "He's the one who started this special part of the genome project rolling. He discovered the odd chromosomal material two years ago, made the first transformations into binary, and said he eventually got some text up on his screen."

"You don't believe him?"

"Well—"

"Never mind," I said. No point in going over that ground again. "What did the text actually say?"

"Some kind of history lesson," Hertzberg said. "It wasn't gibberish, but it didn't make much sense. Even had a copyright notice at the end," Hertzberg laughed. "That's why, to be thoroughly frank with you, I keep emphasizing that I have serious doubts that this project will ever pan out. Seems to me a much more likely explanation for what Manny saw on his screen is that his computer somehow dumped some text from another file into what he was working on. It's happened to me from time to time—I once found part of a very personal letter I had written months earlier right in the middle of a grant proposal I was about to print out and FedEx. Damn good thing I caught it in time—"

"I can imagine," I said. "Where can I get in touch with Klein?"

"You can't," Hertzberg said. He paused for a long second, then spoke in a much lower tone of voice. "Look, I know what you'll be thinking when I tell you this. But believe me, the stroke was entirely natural—Manny had a long history of them. And the one he got after discovering this chromosome material was, well, very big. He was out like a light. Seventy-one is too young to die these days, but at least he had a satisfying life."

Hertzberg was right about what I was thinking. A death of one young scientist and I guess I had to go with the lieutenant: it was most likely murder. The death of two scientists, both working on the same project: jeez, I'd been down twisted paths like that before.

Prospects for Jenna Katen suddenly were looking up.

I couldn't say the same for the rest of the world.

"All right. Who can I speak to for more information about Klein?"

"Jenna's your best bet," Hertzberg answered. "She was Manny's research assistant."

Short-lived reprieve for Jenna. The fickle scales of probability were tipping against her again.

I've always found Neapolitan food to be good accompaniment to the resolution of crises. But I wasn't there yet, not by a long shot. I didn't know enough. I invited Jenna to lunch at Taste of Tokyo in the Village.

I noticed more of her eyes this time. They were an absolutely alluring shade of green with flecks of violet. Lucky would be the guy who saw to it that the DNA for those eyes made it

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into the next generation. But I had more important things to think about right now.

"Glen didn't die of old-fashioned natural causes," Jenna said.

"We agree," I said. "Death by natural causes is a process—like Michael Baden says—you see a history, however subtle, of body breakdown that leads to the circumstances of death. Even in heart attacks and strokes. We found no history like that in Glen. Something else was at work there."

"Who's Michael Baden?" Jenna asked.

"Used to be Chief Medical Examiner in New York City. Testified in the O.J. trial."

"But I didn't kill Glen," Jenna said.

"Well, that's the part that, to be straight with you, we're not as convinced about. If Glen didn't die of natural causes—if the breakdown of just about every major system in his body was triggered by something *un*natural, as it almost certainly had to have been—then the cause of death was accident, suicide, or homicide. There are no other choices. We have no evidence, really, that any one of those three more likely happened than the others. But the guy is dead. You were in the room with him. That moves the needle just a bit into the murder part of the meter, with your shade of lipstick, as they say."

Jenna sipped her green tea. I could see her lips quivering around the edges of the hot cup. They had no lipstick on them. Just soft and pink. "I didn't say Glen didn't die of natural causes," she said.

"But—"

"I said he didn't die of *old-fashioned* natural causes," she said.

"Meaning?" I asked.

"I tried to tell you in your office on Tuesday," she said. "Somehow the words on the screen killed him. The words that came from the chromosomal material. I'm not sure how—but that's about as natural a cause of death as you can get—death by DNA, or more accurately, by transformed DNA-algorithms on a screen."

"Is that what killed Emmanuel Klein?"

She blanched. "He wasn't a young man. Everyone says he died of a stroke."

"What do you say?"

She took another sip of the tea, sucked down a gulp. "He died of the same thing as Glen," she said very quietly.

"And you were there both times—or at least working, or involved, with both of them, right?"

She didn't answer.

"Look, you seem like an intelligent, sensitive person. I want to help you—I want to believe you. But you've got to be more open with me. On the face of it, you're in a bad position here. You have a connection with two people who died—one mysteriously, maybe the other mysteriously too. Cops don't like coincidences—they're like red flags to us. There's a common denominator here. And I think you know it."

She got up as if to leave.

"Not a smart move," I took her hand. "Believe me, things can get much worse for you, in a hurry." I sighed. I didn't like badgering her, frightening her, but I had to get

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through to her. "OK, let's try a different tack. Why'd you lie to me about not seeing anything on Glen's computer screen?"

"You saw them?" Her eyes were wide.

"Just a fading sliver. Why didn't you tell me?"

She sat down heavily, shaken. "It's personal," she said.

"Obviously—this whole thing is personal. But—"

"No, I mean the words were personal," she said. "I should have told you. I'm sorry. But it was too painful. To think that I—I just couldn't deal with it anymore on Tuesday. I just wanted to leave. I should have told you."

What was she talking about? A Dear John letter on the screen? That's what she thinks killed Glen Chaleff?

"The chromosomal material that Manny and Glen were working on came from me, from my body. My words killed them. My body's the goddamned murder weapon."

The sushi and tempura arrived. I looked at Jenna a long time. "So you're saying you're a—what?—a carrier of some type of genetic code that when transformed into words kills anyone who happens to read it?"

She nodded. "So far I'm the only one—as far as I know. The strange DNA material has been found on 8 percent of the X chromosomes we've examined. I told you that. But so far mine's the only one that's been translated all the way into English words."

"How'd you get involved in this to begin with?"

"Manny—Professor Klein—first came across the special DNA in a graduate student at MIT. Standard procedure—lots of students give DNA samples for this kind of research. I'd already given some of mine out at CalTech. Manny put out a request on the Internet—hundreds of scientists around the world were on his list, each already had DNA samples from hundreds of students and locals. Mine came up positive—the special DNA is easy to spot once you know what you're looking for. I wanted an excuse to come back East. I got in touch with Manny and asked if I could join his team. He said sure. He was that kind of man. If I'd known that my DNA would kill him I'd have taken every bit of it back and grabbed the next plane to Antarctica. But even after he died I wasn't sure. I mean, people get strokes. But now it's happened again. This—this *insanity* in my DNA has killed two fine people!" She slammed her fist on the table. The tea in the cups shimmered, along with the tears brimming over her eyes.

I put what I hoped would be a consoling hand on hers. "Have you spelled this out in detail to Hertzberg? Why hasn't he stopped the project?"

"You've talked to him, right? You know what he's like," Jenna said. "He's an Occam's Razor man—he goes for the simplest explanation. He's comfortable with thinking Manny died of a stroke. He'd probably rather believe that I killed Glen with a chemical that left no trace than Glen was somehow killed by the words on the screen. He'll always pick the mundane rather than the exotic. He's a classic example of Kuhn's workaday

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scientist—don't rock the current paradigm, milk it for all it's worth."

Yeah, that jibed with the impression I already had of Hertzberg. Would take a few more bodies in his face before he'd notice—and by then who knows what kind of genetic demons would be let out of the bag.

"Look, we're really talking in the dark here," I said. "Any chance you made a copy of the, uh, offending words, so I could see what they looked like?"

"No," she said. "They're too dangerous—they already killed two people, for god's sake. I don't want to take the chance—"

"All right," I said. "I understand. But can't you at least summarize the gist of what they say, so I can get some idea of what it is you're talking about?"

She considered, then nodded. "First you scan the exact chemical composition of the chromosomal material. We use a new kind of polyacrylamide to do the electrophoresis, the imaging, if you need to know. Gives an extremely clear image, especially good for small nucleic molecules. And the results, as you know, fall into a clear binary series. Then you transform that series to an ASCII table—and in Manny's case, in Glen's too, they got words. . . ."

"Right. First the Indo-European proto-language, Hertzberg told me, then the tenuous English translation."

Jenna nodded.

"And the translation said?" I asked.

"It comes out to about three paragraphs—"

"Paragraphs?"

"Yeah," she said. "Paragraphs. There was a small amount of null material between sentences, and larger amounts after three groups of sentences. So we called them paragraphs."

"OK," I said. "Sorry for interrupting. Please go on."

"Well, the sentences talk about how intelligent species can leave their marks in history. How some, like the human species, have left some of their marks in stone, and these have survived. And how these could be easily recognized by other intelligent people—or species.

"We're not really clear whether the word in that paragraph is species or people.

"Then the text continues with what looks like a question:

"But what of species who lack the capacity to work in stone, to leave their records in unchanging media? How might they tell the future about their existence? They might try to leave a marker, a message, in a different kind of stone, a living stone, a medium—a medium over which they had power.

"And the notation of life—as the text seems to put it—was their medium. They must've had the capacity to penetrate our DNA, maybe rearrange it, and leave this message.

"And the message says it will be passed on from generation to generation, without knowledge of the bearers, and it will therefore last longer than any message carved in non-living stone."

I whistled.

"Wild, I know," Jenna said. "I mean,

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there are lots of individual words in there that we're not completely sure what the meaning is, but that's our best estimate as to the general sense of it."

"So what are we talking about here? Intelligent pieces of viruses that can penetrate our chromosomes, our DNA, and leave messages for us? Intelligent aliens who were able to perform genetic engineering on our ancestors, and leave their calling card in case we had further business?"

Jenna made a helpless gesture. "That, and every possibility in between," she said. "I don't know. I didn't say they were viruses. I just said that was the thrust of the message they left—in me. I saw it. Twice." Her lips were quivering again.

"All right," I said, and tried to give her a reassuring smile. Though I didn't particularly feel that way. "And was that all there was? That was the entire text on the screen?"

"That's the substance of the message," Jenna said. "There was something more at the end—a sort of notice I guess."

"Tell it to me," I prompted.

She closed her eyes, as if trying to get these words exactly. Apparently she felt they in themselves posed no threat. "Anyone who reads these words, who possesses our codes, is free to use them. As allowed under our Copyright Notice."

"Copyright Notice?" So there it was. I was glad Jenna was at last being honest with me.

She shrugged. "That's what the ASCII translation table printed out in English. The newer approaches try to go for figurative rather than literal translations where possible—they convey the culture with more flair, though increase the likelihood of error. The proto-Indo-European was closer to Proclamation of Possession, or maybe Announcement of Ownership Privileges—I've become an expert on that damn language, already, believe me. Truthfully, we didn't pay all that much attention to that last part. The stuff in the body of the message seemed much more important."

"Hard to believe that some non-human intelligence would share our notion of copyright," I said.

"Harder to believe they could create a code that could be rendered into something that looks anything like Indo-European, and store it in some of our chromosomes," Jenna said. "But there it is. And the sense of property, possession, is very old, biologically."

"You mean like mice pissing—urinating, sorry—to mark their territory?"

"Right," Jenna may have smiled, first time. "And hamsters mark stones near their dens with secretions—ethologists say scent marks are chemical property signs. It's all over the natural world. Birds, fish, even insects mark and defend their property. And the closer we come to human beings, the more abstract the notion of property becomes. Monkeys, baboons, chimps have all kinds of very complex expressions of property, aggressively excluding this or that member of the troop, family, whatever from the privileged circle of users."

"So maybe the authors of your text were human," I said.

"Well, could be," Jenna said, "And

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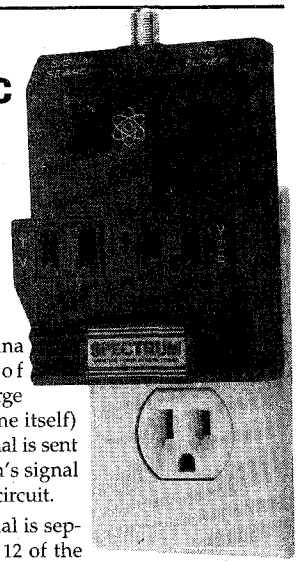

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who really knows what people—any species—were really capable of seven or eight thousand years ago."

"That's the first sign of Indo-European in human history?" I asked.

Jenna nodded. "Nostratic supposedly goes back even further—more than 12,000 years—and has some resemblance to Indo-European, but its existence is still hotly contested. Anyway," she took another sip of tea, with steadier hands this time, "the chromosomal algorithms print out like Indo-European, or something very close to it."

"How do we know the linguistic DNA wasn't inserted into the genome more recently?" I asked.

"We don't—not for sure," Jenna said. "But the 8 percent of X chromosomes with the odd material comes from people all over the world, many way off the track of usual scientific research. Doubtful that an insertion of recent vintage could have that kind of in-depth dispersion. No, I think we're on reasonable ground assuming that the authors of the text, whoever or whatever they were, were contemporaries of early Indo-European. Our problem then becomes how to account for such early people—if they were people—having any sort of gene-insertion technology. But like I was saying—like the message itself says—all we really know of the distant past is what has come down to us in obvious long-lasting media like stone, bone, petrified wood. People in Asia probably did things that would surprise us in bamboo, but all that's disintegrated now. I don't find it impossible to consider that some early human group, speakers and writers of an Indo-European root language, found a way to manipulate DNA. Even non-literate groups show enormous sophistication in deliberate breeding of animals and plants. And if our Indo-European gene-authors could do that, inserting a message that could play out on today's computers doesn't seem impossible either—DNA and computer codes operate in similar ways, both prescribe patterns of organization. Adleman's already demonstrated that DNA in a test-tube can be used to compute solutions for mathematical problems. And they just had to do it once—encode their message into DNA and attach it to the X chromosome just once—all it required was one florescence of their culture. The knowledge to do this could have come and gone all in one or two hundred years. And after that the natural process of DNA replication would see that the message would live on and on. That's the beauty, and the horror, of it. We have in DNA the most effective of all known replicative devices."

"Your perception is impressive, for someone—"

"For someone just a few years out of grad school? For someone so young? Not really. This is my *life*. I guess in more ways than one."

"I know," I said. "That's the problem with most of these quests to understand who we are, where we were, where we're going, isn't it? Sooner or later all the fine science boils down to lives at stake." I closed my eyes, opened them, focused entirely on Jenna's face. "Until we can relate what that prehistoric Stephen

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Jay Gould or whoever wrote, connect that to Glen Chaleff's body falling apart, maybe Manny Klein's too, your life is the one at stake here in the short run. Doesn't matter how appealing your DNA-to-Indo-European-ASCII hypothesis is, the cops won't care. They'll come after you for Chaleff's death. And in the long run. . . ," I shuddered, "well, if something in those words killed Chaleff and Klein, then who knows how many others are at risk."

"You believe in my work, then?" Jenna asked, for an instant more pleased to have an ally in her adventures in knowledge than frightened about where that knowledge might be taking her.

"Let's just say I have a very open mind." But the truth was my mind was set—on finding a way out for her.

"Two people are dead," Jenna said. "There has to be a connection."

The Lieutenant informed me the next morning about a connection that didn't work to Jenna's benefit at all. "Chaleff was dipping the wick with a blonde. Going on for at least a few weeks. Three witnesses saw Katen throw a glass of wine in his face and scream at him about it at a party week before last. There's the motive."

"Yeah? And how exactly did she do it? With a magic wand?"

"That's for you to find out, Doc."

I called Jenna and asked if I could come over. She lived in a new highrise in the West Village. She obviously had money.

Her face flushed when I told her about the witnesses at the party. "So what?" she said. "Lots of people fool around, lots of people scream and yell at each other. Doesn't mean I killed him, for crissakes."

"I'm more concerned that you didn't tell me," I said.

"What? You want a complete exposition of my life? You want a calendar of every fight I had with Glen?"

"No," I said. "Look, this isn't going well for you. I tried to tell you that yesterday. Cops are like hounds moving in concentric circles—once they get a sniff of the quarry, they go round and around, tighter and tighter, until they close in totally and arrest you. And don't believe the movies and TV shows—once they arrest you your chances are not very good. You're near the pit now. You've got momentum against you. We've got to come up with some sort of evidence of what you're talking about, soon, or the situation may be out of my control."

"What kind of evidence?" Jenna asked. "I've already told you what I know."

"Real evidence," I said. "Not just your rendition of the words on the screen. I'm talking about firing up your computer, putting a disk with a binary map of the chromosome stuff in the drive, running the ASCII/Indo-European transformation, and videotaping that whole process including everything on the screen."

"And then what? Running it on HBO as America Under Cover and killing the millions of people who watch it?"

"Well, if it came to that, I could probably get some prisoners on death

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row to volunteer to read it, but I don't think reading it can kill anybody."

"Why not?" Jenna asked.

"Well, for starters, you obviously looked at it and you're still alive. And I saw the words 'Copyright Notice' and I'm still in peak condition."

"That was just one phrase," Jenna said.

"Of course," I said. "But your survival and my survival certainly suggest that whatever's going on with the text, just reading it isn't *ipso facto* lethal."

"So where are you headed then? Back to proving by process of elimination that *I* killed Glen?"

"No, I don't think that either. All I'm saying is that something more than just looking at a screen is the culprit here."

"What, then?" Jenna asked.

"I have an idea," I said. "But first things first. Can your computer handle the ASCII transformation?"

Jenna nodded.

"I assume you have some of the binary codes from your, ah, biological system available on disk?"

She nodded again. "I already have the Indo-European proto-language rendition of my DNA message on disk. Part of this phase of the research was to see if more than one programmer could come up with the same English words independently."

"OK. Then all that needs to be done is the final translation into English. I brought this new little camcorder along with me from my office—I can set it up right there in the corner." I slipped the three-pound wafer out of my briefcase. "How long would it take you to get the words on the screen?"

Jenna was hunched over her computer, totally enmeshed in her work. She jabbed a key and leaned back, hands clasped around the back of her neck. "About seven-eighths complete at this point," she said. She had that look of total satisfied absorption I'd seen many times in faces of researchers.

"Good. The camcorder's all set to record, the printer looks good too." I fiddled with the paper tray one more unnecessary time. Paper—marvelous invention. I didn't like the tendency of those words on the screen to fade, and I never put 100 percent trust in any camera. A paper printout was just the ticket to give me a reliable permanent record of those words.

"You're sure you want to go through with this?" Jenna asked, her expression suddenly changed. The larger realities apparently were still very understandably pressing her.

"I'm sure," I said.

"You know it's possible that the reason that I read it, and haven't been harmed, is that the DNA source code is mine. . . ."

"Possible, yes. Lots of things are possible. But I think the key point here is that Manny and Glen did something more than read it. I can't imagine that just *reading* some words on a screen could kill—"

She shook her head. "I really don't think we should go on with this."

I could see she was working herself up—

"I mean," she continued, "even

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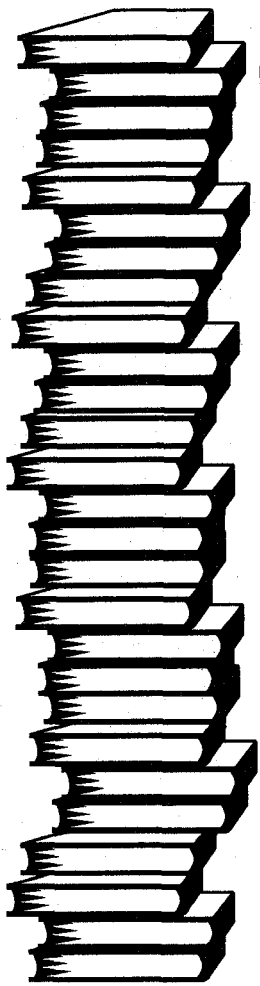

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from my selfish point of view, if you die here, with me right next to you, there'll be no way the police won't believe that I killed you. And even if that wasn't the case, I don't want you to die—"

"I've already taken care of that," I said. "I left an outline of my theories about this case in my desk before I came here today. If something should happen to me, the lieutenant will read that and you'll be in the clear. You've got to trust me on this."

"I *do* trust you," Jenna said. "I like you—that's why I don't want you to die. I mean—"

"No one's going to die," I said. "I'm not going to be sitting there staring at the screen like a wide-eyed lamb when the words come up. We'll be in the other room. The video recorder will start automatically. The words will print out on the laserprinter. Whatever killed Glen and Manny, it surely wasn't the meaning of the words—you've already recited that to me—it had to have been some kind of energy that was generated from the computer, released somehow along with the words. I've been saying that I don't think that just reading the words released that energy—I don't see how it could. But even if it did, there's no way that energy could be carried along to a simple printout on paper."

Jenna still looked doubtful. "What about the videotape?"

"We won't look at it directly—I'll use the digital scan to confirm that something was in fact recorded, then get it over to the lab for further testing."

"I don't know," she said.

"Jenna, I'm appealing to you not only as a woman who may need this evidence to save her own freedom, maybe even her life, but as someone who cherishes the pursuit of knowledge. You and your colleagues started this. Who knows what lessons this DNA message may ultimately hold for the human species? We've got to see this through."

She sighed, shaking her head, but she swayed back to the computer. I could see her body, first limp and sagging, now energized and vibrant as she returned her full attention to the work on the screen. "We should have the text up here any minute now," she said. "The program will beep thirty seconds before the words all become clear on the screen, so that'll give you enough time to get into the next room. Don't be like Lot's damn wife—make sure you don't turn around and peek at the screen."

The camcorder clicked and whirred into action.

The phone rang. "Should I get it?" I asked.

Jenna motioned yes.

"Hello? D'Amato. Phil. Fine, thanks. Uh huh. I see. Jeez—how? OK. I understand. Of course I will. I'll be back to you."

The computer beeped. "Words are on the screen in thirty seconds," Jenna turned and announced with a mixture of triumph and trembling.

"That was Hertzberg on the phone," I said.

"What's he found? Anything of interest?" Jenna rose from her chair.

"Someone else on the project

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died—of 'natural' causes. Denise Richter. You know her?"

"Of course I know her," Jenna sobbed like someone stuck by a knife. "Of course I do. I didn't know her well but, for god's sake, how'd it happen this time?"

"Same as the last two," I said. "At least you're off the hook now on the murder charge."

"Oh god. I just thought of something."

"What?" I said.

"Denise was using my genetic material. Glen told me the batch she'd been working on had been accidentally ruined—the stain was too strong—so he sent her some of his stock, which was mine . . . oh god." Now not only her lips but her entire body was quivering.

"It's OK," I said, and I put my hand on her shoulder to calm her. "Hertzberg's putting a halt on the project. That's why he was calling you. I guess he has the requisite number of bodies now—"

"And I'm gonna put an end to *this*," Jenna cried out, and I saw her hand reach down to the keyboard.

My hand shot out in reflex, faster than Jenna's. I caught her wrist in midair, jerked it away from the keyboard. "Don't," I said. "We've got to go through with this."

"Are you crazy?" she screamed. "How many more dead do you want?" And her fists were pummeling my chest, unclenching into hands that were frantically trying to push me away, break free so she could get to the keyboard and prevent the words from getting on the screen, maybe erase all the crucial preparatory work on her hard disk as well.

But I set my arms firmly around her body and moved her out of the way. And I had a clear view of the screen.

And god help me, I couldn't stop myself.

I looked and read.

Jenna's voice came to me and said, "Are you OK?"

The words on the screen were as Jenna had described them in the restaurant. Down to that peculiar copyright notice that I had seen a fragment of in Glen Chaleff's apartment, and Jenna had quoted verbatim to me in the restaurant.

"Anyone who reads these words, who possesses our codes, is free to use them. As allowed under our Copyright Notice."

"Are you OK?" Jenna asked again. "How do you feel?" And I could see she was staring at me intently.

"So far, so good," I said. "Just the usual hunger rumblings in my stomach."

Jenna continued to stare at me, as if keeping me in the crystal-clear focus of her green-violet eyes would prevent me from dying.

"I'm OK, really," I said. "I'm sorry I had to shove you out of the way." Actually, my body wasn't—she'd felt very good with my arms around her. But that was hardly the point.

"Oh god," she put her arms around me and pulled herself close. Professional, think professional, I thought. She's still officially a subject in a murder investigation, though I knew she wasn't guilty. I controlled myself to the point of allowing myself just one

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or two strokes of her soft brown hair. "I'm so glad you're all right," she said, crying. "What am I? Some sort of goddamn Typhoid Mary of an ancient genetically engineered curse?"

"No," I said. "This isn't a disease—even though I said virus the other day. I mean, it could be a virus, it could be some early advanced variant of the human species, hell, it could be aliens from outer space after all. The point is that whatever, whoever rigged this booby trap, was an intelligence. And disease isn't intelligent. Deadly sometimes, yes. But not intelligent. And this isn't a curse either. We're dealing with fact here, hard science, not magic—something in your DNA. And that's about as real a reality of life as you can get. You know that."

"But what's the booby trap?" Jenna asked, pulling herself away and drying her eyes. "You're still alive. Even though Manny and Glen and now Denise. . . ." She shook her head.

"The answer has to be in the words on the screen—the last two sentences if I'm right. The words of course are not exact—how could they be? Hertzberg says you have no way of confirming the accuracy of the transformation. He's right in terms of the usual modes of linguistic confirmation. They can confirm the accuracy of the Indo-European to English part, but not the initial chromosome-ASCII to Indo-European part. How could they? It's never been done before. We're in a technological variant of Plato's Meno paradox here—you have to already have knowledge to recognize, to validate, potential knowledge, so where does the first knowledge come from? But the chromosome ASCII looks like Indo-European—not like Chinese or Korean. So, OK, it may be just coincidence, like Hertzberg thought, but let's assume it *is* Indo-European, or related to it, and proceed from there. Where does that lead us? Hertzberg says there's a high noise component. But no reason to think it's evenly distributed throughout every word in the message. Some of the text on the screen may be way off from its original meaning, some may be right on the money. How do we tell which is which? What does the evidence suggest?"

Jenna held her hands up in an I-don't-know gesture.

"Well," I continued, "we've got three fatalities now as evidence. What part of the text could they possibly relate to? I don't see anything in the history lesson, fascinating as it is, that could be the culprit. But I do see a possible suspect at the end—in the copyright notice. 'As allowed under our Copyright Notice.' Let's assume the noise in that section of the text is low. Let's assume that Copyright Notice, or something close to it, is an accurate rendition. Now: Seen in that light, maybe the deaths make sense as punishment for what's *not* allowed under their notions of property."

"What's not allowed under copyright?" Jenna asked. She cast a sideways look at the screen. I followed her gaze. The words were mostly gone now.

"Let's think about what *is* allowed, first," I said. "The text says it's all right to 'use' the words, or maybe to use the 'codes.' What does that

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mean? How do we use printed words?"

"We read them?" Jenna asked.

"Yes," I said. "And that seems to be OK—at least for me. I read the words and I'm OK. And I have no special connection to these words. They didn't come from my chromosomes."

Jenna nodded and looked at me, still not completely convinced that I would *be* OK.

"All right," I said. "So let's get to the 'codes.' How would we 'use' genetic codes?"

"Well, the most common way is we have sex, reproduce, and the codes create new versions of us. And the codes within our cells create new cells, as long as we're alive."

"Right," I said. "And that seems fine, too. I mean, people reproduce all the time, right, and few seem to die of mysterious natural causes. Most people's cells reproduce OK too, for at least most of their lives. For that matter, Adleman used real DNA codes for his computations—I pulled some summaries of his work off the Net last night—and he's all right. Though presumably he didn't use yours."

"True," Jenna said, not in any mood for my humor. "So where does that leave us?"

"Where it leaves us is at a clearer answer to the question you just asked: What do those words on the screen forbid? Not reading the instructions. Not implementing the instructions—not implementing the genetic codes. Those things are OK. We're 'free' to do them. We can use the words and the codes. But what is that Notice saying, in some sort of implicit way, that we *can't* do? What does a copyright notice seek to protect against?"

"Plagiarism? Theft of intellectual property?" Jenna asked.

"Yes," I said, "but those wrongs seem too subtle for what's going on here. The proscription has to be against something much more basic—more common. Something that Klein and Chaleff and Richter all did, no doubt in all innocence. Something that people do almost without thinking with computers all the time."

Jenna held her hands up in frustration. "What?"

"Do you have a way of automatically making a copy of a file on your computer? You know, giving the command to copy in some sort of delayed way that would allow us to walk out of the room while the copying was taking place—rather than staring at the screen, or being anywhere near it?"

"Well sure," Jenna said. "I can put the copy command at the end of a command chain—a long chain—that would definitely give us time to get out of the room. But—"

"OK, well could you do that right now then—for the chromosome text on the screen and its underlying program?"

"You think that making a *copy* of this triggered everything off?" Jenna asked, disbelievingly. "Making a copy killed Glen and Manny—and Denise?"

"Well, it's a copyright notice, isn't it?"

She entered the delayed command string in the computer, and we

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walked quickly into the next room. I told her not to look anywhere near the computer screen. We looked at the opposite wall—at the hand-me-down shadows of Plato's cave, like dogs baying at the Moon—and saw nothing. No effect at all. A brief play of light on the blue wall, like the heartbeat of a photocopy, maybe, and that was it. The paint didn't even so much as peel.

But the camcorder, which presumably had been recording all this time, made a sharp whining noise and flashed an erratic red light. I turned it off manually, and did a digital scan of the tape. "Goddamnit. That pulse or whatever it was must've erased the whole tape. We've got nothing here."

"What now?" Jenna asked, very tiredly.

"We call in the mice," I said.

A half hour later, my friend Johnny Novino from the Berg Institute at the NYU Medical Center—an animal research lab—arrived with a cartload of white mice.

"What are they for?" he asked.

"You wouldn't believe me if I told you, so I won't," I answered. "And I'd rather you didn't know anything beforehand, so you can conduct a completely unbiased examination if need be."

"Figures," he said, gave Jenna a wink, and he left.

We set up a pair of mice in a cage in front of the screen, and Jenna entered the delayed copy command. We hurried out of the room, and saw the same light kiss on the wall.

But for the mice, it was the kiss of death.

We repeated the act ten times, and produced twenty dead rodents.

"Was that really necessary?" Jenna asked.

"Yeah," I said. "I don't like this anymore than you, but we've got to have redundancy to really pinpoint the exact cause of death here. Better them than us."

"Poor little things couldn't even read the damn text," Jenna said, then rushed into the bathroom and threw up.

The lab report came back five days later.

"Phil, you know about circadian rhythms?" Johnny returned my call about the report.

"Well, as much as the next guy," I said. "They control our waking and sleeping patterns, and are governed in some way by light. They seem to affect the brain's sleep center through the optic nerve."

"That's right," Johnny said. "So what seems to have happened to your little mice is some stimulus, likely some kind of light, switched their circadian rhythm to infinite awake—as in impossibly high blood pressure, instant heart failure, instant everything failure, adios muchachos."

"And your evidence for that?"

"Like the report says," Johnny replied. "Incredibly high residues of serotonin—natural chemical found in the brain, contributes to the sense of wide awakeness, well-being, also raises the blood pressure."

"So at least the mice died with a smile in their hearts," I said, and filled him in on all the details.

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"Jeez," Johnny said. "Likely Glen Chaleff died of that too, then. But your guys must've missed it because serotonin's a natural compound, on no one's list as an abused drug. We missed it too on the first six mice. But there's no doubt about it now. So my best guess for the full trajectory—assuming you didn't administer serotonin to the mice yourself—is light provokes extreme circadian reaction, causing huge overdose of serotonin, causing lethally high blood pressure, causing heart attack and general system failure across the board. The only real mystery here is what the hell kind of light could do that?"

"We're working on it," I said.

"But how could a people eight thousand years ago know how to make our current computers emit a fatal light?" Jenna asked over dinner at my favorite Italian restaurant the next evening.

"I don't know," I said. "But that's no more a puzzle than that they could insert a special binary code in some of our chromosomes that could read out ASCII Indo-European—and you've been willing to believe that. We don't understand the relationship of electricity to light in anything like its entirety even now. Maybe they did—or at least knew something we don't yet. Maybe they had some kind of organic computers—that ran on DNA algorithms like Adleman's math calculator—except rather than solving equations they caused electrons to form light patterns that in turn controlled circadian rhythms."

"Lots of primitive people understand circadian rhythms," Jenna said. "I can believe that. And the DNA computers—"

"Rotted away," I said. "Or maybe they're in us. Who knows?"

"Their media were life and light," Jenna said, "more ephemeral, but also much more lasting, than just plain stone."

And the red wine came and we both got good and drunk. . . .

Some things are too bizarre for me ever to put in a public record—not if I want to keep my job.

Hertzberg called an end to that small project within a project, but Jenna's going on. She and I contacted all of the original researchers, explaining our theories to them. Most thought we were nuts, a few believed us. Doesn't matter if they believe us or not—the important thing is that those who pursue this aren't likely to risk making a copy of the text any time soon. We can't do anything more than alert them—to the enormous possibilities of this research as well as its dangers. The rest is up to them.

The problem is we don't have any evidence. Videotapes, motion photography—all equipment seems to be blind to that deadly little light, able neither to transmit nor record it. We can make no record of what happens when Jenna's chromosome text is copied, no record of that thin bright thread that's emitted. Puts a crimp in any research program.

And of course we have no copies of the text. Videotapes, photographs of the screen, endless printouts—they all come out blank too, as innocent of

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DNA and Indo-European as the driven snow. The lethal light hadn't erased the video-recording that first time; the recording hadn't occurred to begin with.

"What kind of words can appear on a computer screen and defy recording, printing, on any other piece of equipment?" Jenna had asked.

"Maybe the kind that kills you if you try to copy them," I'd replied. "Maybe the words don't really exist on the screen at all. Maybe the program somehow projects them right onto our optic nerve."

But the corpses existed all right. Three good people, and a pile of who knows how many rodents now. They, ironically, were the sole proof that the ASCII derived from the DNA not only looked like Indo-European, but was Indo-European or something much like it—stark confirmation that at least some of those words meant what they said. Jenna thinks that might be enough to give us a shot of getting something published, maybe in one of the fringier scientific journals.

We—Jenna—stumbled upon something, yes. A primordial copy protection scheme. A copy protection technique from Hell. DNA as ultimate shareware: *use* this little program to your heart's content, enjoy it, be fruitful and multiply with it, implement it—let it implement you—but don't copy its words without authorization. Not unlike many of our own computer programs and books, really. Except authorization to copy the Indo-European DNA program has likely been quite impossible to get for something going on eight thousand years or more.

I guess I was able to see this when Jenna didn't because, well, my job is always at the intersection of science and the law, of life and property and the canons for its protection. And this canon was effective, I'll give at least that to its authors.

Who were they? They apparently left their message in the far reaches of some 8 percent of human X chromosomes, their precious copyright notice in who knows what fraction of those. Maybe they were in some way responsible for setting the human species on the course it took.

Why would they attach such a deadly penalty to a violation of their notice? In that they were no different than organisms throughout the animal kingdom ready to protect their turf by deadly force. Jeez, didn't I read just last week that even some trees emit a resin that kills any insects that tread too heavily on their bark.

Only further research will tell. And that, obviously, Jenna and her colleagues will have to do exceedingly carefully. Like they were researching a deadly new virus.

In the meantime, we'll just have to take what pleasures with our DNA we more or less safely can. Those we are "free" to enjoy. . . .

I ran my hand against the skin of Jenna's back. She lay sleeping on my chest. She'd been cleared of all charges—Denise's death had seen to that—she was no longer a suspect in any way.

I often wondered if somehow hers was the only one of the 8 percent of the X chromosomes that not only had the binary DNA material, but the DNA

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that yielded that brief meditation on modes of preservation, along with the copyright notice. Not likely, I guess. Further research would answer that question, too.

But in the meantime, the sensible course would be to assume that Jenna was the only one. She was the only one we knew about. And if that was so, then my responsibility to the human genome, the human species, was to see that Jenna's special DNA survived. Not only in frozen storage, which Jenna had already taken care of, but in actual in situ living usage—the far more reliable and time-honored way of getting DNA into the future.

I, of course, knew, in spite of what I had told her that day in her apartment when we'd first glimpsed the light, that what she carried in her DNA was indeed both a blessing and a curse—a blessing in terms of the knowledge about our very origins that it could hold, a curse in terms of the price that three unknowing people had already paid in quest for that wisdom. A mechanism of beauty and horror, as Jenna had said herself. But to the degree that it was a blessing, I had to help it survive.

Yes, until further research could sort all of this out, I was willing to do my part to insure that the text she carried was passed on to future generations in its original form, where minds wiser than ours might come to better understand it, plumb it for its secrets, and neutralize its deadly penalties.

After all, the lethal qualities of the DNA she carried didn't extend to reproduction. That, the copyright notice said, she was free to do.

I was prepared to help her do just that.

I moved my head over and kissed her face.

After all, I was a forensic scientist, but a scientist first, and though I'd pretty much reached the limits of my capacity to contribute to the ongoing research here, that didn't mean that I'd shirk my responsibility to help the subject of the research live on.

That, and I so enjoyed looking into Jenna's green-violet eyes when they were happy. . . . ■

"Never make a pet of a bear," a zoo keeper once told me, with what struck me as needless alarm. I make wrong moves from time to time, but I have never even come close to making a pet of a bear.

—Will Cuppy

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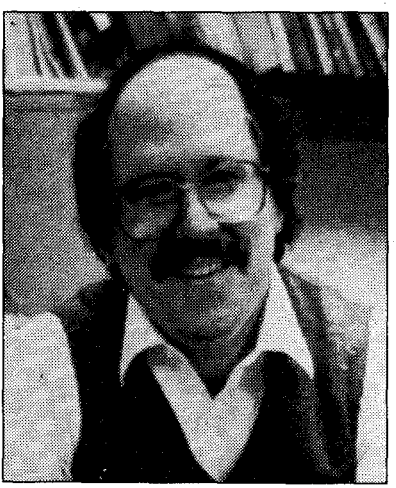
BIOLOG Jay Kay Klein

In the seventh grade, Paul Levinson was called down for a meeting with the school librarian. She told him he was reading too much science fiction. He switched to the public library and is now living in what the librarian considered a far-fetched, unrealizable future. His is a computerized world, focused on peering ahead for what comes next.

A life-long resident of New York City, with its global ethnic mix, Paul was strongly influenced by forward-looking thinkers. In America's premier city, the first and for many years the only sky-scrapered expression of the World of the Future, John Dewey with other futurist philosophers and educators in 1919 founded the New School for Social Research. Paul is now a professor in the Media Studies Masters of arts faculty at the New School for Social Research.

After attending New York's City College for several years, he dropped out to write folk-rock, publishing over 100 songs. Free-lance article writing and think-pieces followed, along with odd jobs. Back to school, a bachelor's degree from NYU, a master's in Media Studies from the New School, and a doctorate in Philosophy and History of Media and Technology from NYU.

For the past ten years, Paul has run an ultra-modern education service he founded called Connected Education, Inc. Through on-line computers, he offers courses in the social sciences accented by degree programs at the New School and several other major universities. This number increases as administrators get ready to live in the



Paul Levinson

21st century. Technology now permits students to live far away from campuses and even continue full-time employment requiring travel. Before satellite-connected phone links, *Analog*'s L. Sprague de Camp conducted courses by mail as Principal of the International Correspondence School's Inventing and Patenting faculty. Paul's

(Continued on page 81)

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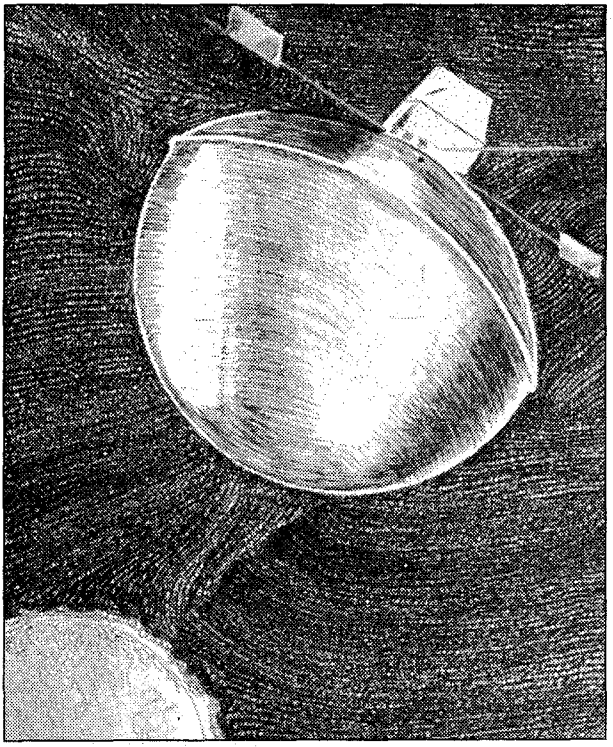

We don't have to go all the way to the stars to find useful, achievable goals in interstellar space.

Illustration by C. Bangs

Dr. Gregory L. Matloff

VOYAGE TO THE SUN'S GRAVITY FOCUS: THE FIRST STARSHIP?

The stars are in immediate reach for our evolving global civilization. One of the many candidate star drives has emerged as the most promising, at least for interstellar missions of centuries duration. Even more miraculously, a near-term extrasolar destination has been discovered that might allow a modest robotic mission beyond the heliopause in the not-too-distant future.

If we can project a robotic spaceprobe with an astronomical payload to a distance equal to or greater than 550 Astronomical Units (AU) from the Sun, experimenters can utilize the Sun's

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"gravity focus" to greatly amplify electromagnatic signals emitted by objects occulted by the Sun. Amplifications of 100 million are not infeasible to studies of distant energetic astrophysical objects—neutron stars, black holes, Seyfert galaxies, etc.—or directed searches for radio leakage from suspected extraterrestrial civilizations are possible. Unlike the more conventional optical focus of an optical system, the gravity focus of a massive celestial object is a straight line rather than a point. As a consequence of General Relativity, gravity-focus-aided observations of a Sun-occulted object can begin at 550 AU and continue indefinitely as the probe's solar distance increases.

Before considering this exciting mission possibility, it's worthwhile to review the current state of thinking about interstellar propulsion possibilities. This is because, by happy coincidence, the best propulsion choice for a mission to the Sun's gravity focus is also one of the most feasible interstellar propulsion options, from technological, economical, and environmental standpoints.

The first comprehensive scientific/engineering comparison of interstellar propulsion techniques took place during the 1970s and '80s and was published in special issues of *The Journal of the British Interplanetary Society (JBIS)*. I was privileged to play a role in these investigations.

Coming out of the euphoria generated by the successful Apollo Moon landings, it initially seemed that the stars were only a few steps away. But as the research and dialogue continued and the BIS-sponsored Project Daedalus matured, the difficulties of starflight began to penetrate the consciousness of even the most enthusiastic devotee.

Time and Distance: The Main Obstacles to Starflight

First of all, the stars are very far away. Even light, traveling at 300,000 kilometers per second, requires a bit more than four years to cross the gulf separating our Solar System and the nearest neighbor star—the Alpha/Proxima Centauri triple star system.

The Wonderful (But Impossible) Hyperdrive

You might first consider the wonderful science fiction device of the "space/time warp" to take a shortcut through hyperspace. But the only suspected space warps that may exist naturally are collapsed stars (commonly called black holes or singularities). Since carrying a stellar mass around in our warp engines seems a mite inconvenient, we might try instead to augment or duplicate the effect with angular momentum (spin) or magnetic fields. All theoretical attempts to accomplish this goal have failed—frustrated by the requirement to spin a large object at close to light speed or routinely pulse magnetic fields to strengths greater than those found at the surface of a neutron star. Even if we could generate an appropriate singularity as a gate to hyperspace and a twin "white hole" as a doorway back into normal space-time, there are theoretical doubts that a black-hole/white-hole pair (also called a wormhole, as any *Analog* reader or *Star Trek* fan knows) will remain stable long enough for a spaceship to take advantage of.

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OK, so hyperspace seems a bit out of reach. Let's next consider spacecraft capable of accelerating to velocities close enough to the speed of light (often abbreviated as "c") that relativistic time dilation greatly reduces the voyage duration from the point of view of the shipboard crew (not from the point of view of Earthbound observers). The two candidate propulsion systems that have been most studied are the interstellar ramjet and the antimatter rocket.

Improbable Relativistic Possibilities

Also called the Bussard ramjet after its inventor, the interstellar ramjet seems at first glance (and even after a fair amount of analysis) to be the ideal relativistic stardrive. Using an appropriate magnetic field configuration (or "ramscoop"), interstellar protons are collected from a wide area in front of the speeding starship. Collected ions are then directed through a thermonuclear reactor capable of fusing four protons to form helium and energy, in an analogous manner to the natural fusion reactor in the interior of the Sun and most other stars.

Most ramscoop geometries fail. In fact, with the possible exception of Brice Cassenti's toroidal-field geometry, ramscoop fields tend to reflect interstellar protons and act as an effective drag brake or "magsail." But much more significant than the technological problems of scoop field geometry are the real physical problems of reactor design. Proton-burning fusion reactors are immensely more difficult to design than the heavier isotope (deuterium, tritium, and helium-3) machines that may come on line early in the next century. Most fusion specialists suspect that proton-burning reactors may forever be beyond the reach of human technology.

Many less capable (but more feasible) ramjet derivatives have been suggested. The reader is referred to Eugene Mallove/Gregory Matloff's *The Starflight Handbook* or John Mauldin's *Prospects for Interstellar Travel* to review the technical literature.

If we consider the antimatter rocket, we certainly overcome the slow reaction rates experienced by the proton-burning interstellar ramjet. If you combine a mass of antimatter (or "charge-reversed" matter) with an equal mass of ordinary matter, reaction is immediate and pure energy is the final product. Unlike nuclear fission or fusion reactions in which less than 1% of the reactant mass is converted into useful energy, more than 50% of the mass involved in a matter/antimatter reaction can be converted into usable energy and transferred to a rocket engine's exhaust.

If we can learn to generate antimatter cheaply or *if* a cosmic reservoir of this very volatile material can be found, the era of routine, high-speed interstellar commerce will have arrived. Alas, though, such a happy time seems very far in the future indeed! In our region of the Universe at least, normal matter dominates and antimatter is exceedingly rare. A decade of accelerator experiments has revealed that we can manufacture the stuff in small quantities and store it for months. The quintillion-dollar antimatter-fuel cost of outfitting even a

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very modest fast interstellar expedition would cause even the deficit hounds of Washington to blanch!

Nuclear Rockets and Light-Sails: Slow But Feasible Alternatives

In 1984, the Project Daedalus directors Anthony Martin and Alan Bond followed up this engineering study of an interstellar robotic probe with a serious consideration of the ultimate human-constructed spaceship—the "worldship." Worldships would duplicate the terrestrial environment (as closely as possible) within kilometer-long craft constructed of asteroidal material. Reminiscent of Gerard K. O'Neill's Lagrange-point colonies or Arthur C. Clarke's *Rendezvous with Rama*, a worldship would be designed to transfer a human population in the hundreds or thousands to the vicinity of Alpha Centauri within a flight time approximating 1,000 years.

Martin and Bond reviewed the candidate propulsion systems discussed in the literature and dismissed most of them as impractical or infeasible. The only survivors of their analysis were the nuclear-pulse rocket and the light sail.

Nuclear-pulse rockets were first analyzed as part of a secret Cold-War Department of Defense project called Orion. Such notables as Freeman Dyson evaluated the possibility of propelling a spacecraft by the immense force of a nuclear or thermonuclear detonation and tested a number of prototypes with conventional explosives; one of these is on display in the Smithsonian Air and Space Museum. The Atmospheric Test Ban Treaty of 1963 and America's victory in the Moon race doomed Project Orion, but Dyson was able to publish an epochal paper in a 1968 issue of the journal *Physics Today*, that proved large-scale centuries-duration interstellar travel is possible with such a constructive use of the world's nuclear arsenals.

Sadly perhaps for advocates of interstellar travel, the post-Cold-War populations seem more willing to scrap excess nuclear weapons rather than stockpile them for starship propulsion. A more sanitized version of nuclear-pulse propulsion, the electron-beam (or laser) initiated fusion micropellet drive of the BIS Project Daedalus might be preferable on political or environmental grounds.

The Daedalus reactor, which may become feasible in the next century, burns deuterium and helium-3. Although deuterium is a fairly common terrestrial and extraterrestrial resource, helium-3 is quite rare except in the Sun, the solar wind, and the atmospheres of the giant planets. We might learn to mine this resource from the upper layers of the Moon's regolith (which has been exposed to the solar wind for billions of years), tap into the solar wind, or deploy balloon-mounted helium mines in the Jovian atmosphere. In the near-term future, at least, it seems most unlikely that helium-3 mining will be inexpensive enough to allow for an interstellar probe, let alone a peopled expedition.

So only the light sail remains as a near-term candidate for propelling a spacecraft beyond the confines of our Solar System. Conceptually the simplest deep-space propulsion system,

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the light sail was also the first to be suggested. According to a historical review by Louis Friedman, the light sail was suggested in the first quarter of the 20th century by the great Russian astronautics pioneers Konstantin Tsiolkovsky and Fridrikh A. Tsander.

As demonstrated by the pioneers of quantum mechanics, every photon of light has a characteristic momentum. If enough photons impinge upon a very thin reflective surface, the photons can actually accelerate the surface. A light sail is nothing more than an extremely thin (nanometer-micrometer) sheet of a highly reflective metal or metal-coated plastic.

Although simple in concept, lightsail design is quite a complicated discipline. As described by Louis Friedman and Jerome L. Wright, sail rigging and structure, cables, payload location, and the emissive qualities of the sail sheet must all be taken into account.

In 1981, Matloff and Mallove began to investigate the idea of a solar-sail propelled worldship. (A solar sail is a light sail propelled by the pressure of sunlight). A sail as thin, temperature resistant, and strong as possible is unfurled as close to the Sun as possible from a spacecraft moving in parabolic or hyperbolic solar orbit. Sail and payload are linked by cables with the tensile strength of silicon carbide or diamond.

For payload masses of a few million kilograms and a perihelion distance of millions of kilometers from the Sun's center, the thinnest possible space-manufactured 100-km radius sails can project the spacecraft towards Alpha Centauri on journeys of about 1,000-year duration. During the long interstellar cruise, the sail and cable can be wound around the payload to provide additional cosmic ray shielding. The sail can be unfurled at the journey's conclusion to decelerate the spacecraft by radiation pressure from light emitted by the two main Centauri suns.

But as discussed by Mauldin, a possible long-term goal for our emerging global civilization would be construction of interstellar arks capable of reaching Epsilon Eridani or Tau Ceti (two Sunlike stars at about 11 light-years from the Sun) within 1,000-year duration voyages. The solar sail seems inadequate for 1,000-year journeys by peopled spacecraft much beyond Centauri, so Eric Jones and Robert Forward have suggested maser and laser sails.

Maser and laser sails (using solar power broadcast by collimated microwave beams and laser beams respectively) get around the inverse-square law of solar radiation intensity that limits the 1,000-year ark to hops between the Earth and Alpha Centauri. Although certainly feasible in the future, the problems of maintaining beam alignment between the power station near the Sun and the distant starship during a decades—or centuries—duration acceleration run are enormous. If the beam pointing-direction deviates ever so slightly from the sail, which might be light-years distant, the expedition will be lost.

The astute reader will notice that nuclear-electric propulsion (also called the ion drive) has not been considered in our review of feasible interstellar propulsion systems. The ion drive, in which fission-reactor energy is used to

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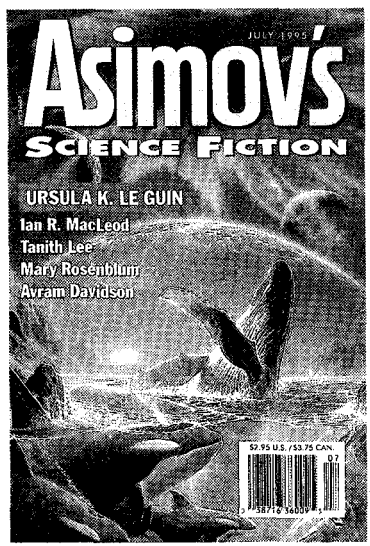

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electrically accelerate exhaust ions, has been considered for application in robotic extrasolar missions such as the NASA/JPL TAU study, in which it could propel a probe to about 150 billion kilometers (one thousand Astronomical Units) from the Sun in a 50-year duration mission (see Jaffe et al's 1980 paper). However, as discussed in 1988 by Anthony Martin and his collaborators, it may be impossible to scale the ion drive up for true interstellar application. Also, the political and environmental problems posed by a fission-propelled space mission in the post-Cold-War world might be very difficult to overcome.

A Mission Emerges

So what are we left with after the elimination process outlined above? Only the solar sail, since 1,000-gigawatt orbital lasers or masers are many decades in the future. Even the solar sails we could launch today, such as the test sail unfurled some months ago from *Mir* station, are a far cry from the space-manufactured hyperthin sheets that could carry us to Alpha Centauri in a millennium. The fastest trip time to that star by a sail constructed on Earth and launched into space is in the neighborhood of 10,000 years.

This is still a pretty good clip—more than 100 km/sec and several times faster than *Pioneer* 10/11 or *Voyager* 1/2. But it's altogether too slow for even the most patient interstellar adventurer.

But, as mentioned earlier in this article, we need not actually go all the way to the stars to productively gain experience in the vast ocean of extrasolar space. If we can project a small robot out to 550 Astronomical Units (about 83 billion kilometers or 0.2% of the separation between the Sun and Alpha Centauri), general relativity predicts that in a very real sense, the entire Universe will open up! An Earth-launched solar sail could reach this point, the minimal focal distance of the Sun's gravity lens, after a flight measured in decades. Such a mission would provide early practice for true interstellar exploration and could be flown with off-the-shelf technology.

Focal: Child of Quasat

Let me emphasize that this robotic mission, which has gone by titles including SETIsail, ASTROsail, and most recently Focal, is a serious aerospace proposal by engineers affiliated with the Alenia Spazio Corporation in Turin, Italy, not an academic exercise. The interest by Alenia stems from an inflatable orbital radio telescope called Quasat, which was proposed to the European Space Agency (ESA). Quasat was to be launched into Low Earth Orbit (LEO) by a European Ariane booster.

Although it never evolved to the construction of actual flight hardware, many of the design elements of Quasat were later used in a radio telescope deployed from the *Mir* space station a few years ago. As part of its contribution to the Quasat study, Alenia constructed ground-test prototypes for experiments in clean rooms and test chambers, and developed procedures for the construction of low-mass multi-frequency astronomical radio receivers.

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I met Alenia mathematician Claudio Maccone in Milan during a December 1990 conference on the solar sail. My interest was in the development and testing in my lifetime of the solar sail as a true deep-space transportation system; Maccone's was in the design of scientific experiments that could be performed by a radio telescope in deep space. Such a program would recoup for Alenia some of its investment in the Quasat study.

During the early phase of our collaboration, Maccone pointed out to me that I had actually pinpointed an experiment that could best be flown by an interstellar solar sail in *The Starflight Handbook*. He was correct; Mallove and I had discussed using the Sun's gravity lens effect to amplify electromagnetic emissions from occulted objects in our chapter on solar-sail starships if the Sun-ship separation is greater than 500 AU.

The first person to publish a paper describing the possible utility of this aspect of general relativity was Von R. Eshleman, in 1979. The Sun, because of its immense mass, can deflect the path of light passing near it. Beyond the "magic distance" of 550 Astronomical Units (AU) from our Sun, electromagnetic rays emitted by objects occulted by the Sun are amplified by a factor of about 100 million. The "hot spot" or disc in which most of the amplified radiation falls is very narrow, perhaps measured in kilometers. The Sun's visible disc at 550 AU subtends an angle of only 3.3 seconds of arc.

Unlike the optical focus of a lens or a mirror, the gravitational focus of the Sun (or other large, gravitating object) is a line rather than a point. Once the probe reaches 550 AU, it can function as a receiver of amplified signals from objects occulted by the Sun as it cruises further into interstellar space. Deceleration at 550 AU is not necessary.

The prime advantage of the sail for this mission is its ability to perform multiple functions. After propelling the payload to hyperbolic (Solar-System escape) velocity, the sail can function as a solar energy collector if it is properly configured. A (rather modest) 30-meter radius sail at 1,000 AU from the Sun can gather four watts of continuous sunlight. If the sail has a spherical or parabolic figure, it can also serve as a radio or optical telescope in deep space both before and after the probe reaches the nearest point of the Sun's gravitational focal line.

As these ideas matured, I had my first direct experience with the phenomenon called "gigantism," the unfortunate tendency of space projects to gain in complexity and cost as they gather enthusiastic supporters. My initial papers with Maccone considered small (5-10 kilograms) "micro" payloads, sail areas less than 10,000 square meters and total mission masses in the vicinity of 25 kilograms. Sail thickness was typically 1-2 microns and 50-80 years were required for the probe to reach 550 AU after sail unfurlment in high-Earth orbit. Because of the low mass estimate, low-cost boosters such as Pegasus would be adequate for launch from Earth. The initial justification for the mission might be a demonstration mission to concentrate on high-amplification radio studies of stars thought to harbor communicating ex-

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traterrestrial civilizations.

But then as we presented the ideas at conferences and looked for backers, many scientists and engineers attracted by the idea began to realize that their favorite experiment package could easily be used to advantage from a platform beyond the heliopause. Soon, as our early papers in *Spaceflight* and *JBIS* blossomed into full-fledged conferences at Turin Polytechnic and New York University, and regular sessions at meetings of the International Astronautical Federation, the payload began to grow in size, as did the projected mission complexity and cost. When Maccone submitted the Focal proposal to ESA, the proposal had thirty co-authors (including myself) and the projected mission cost was equivalent to about $500 million. Who knows what the cost will become if the project is finally approved by one or more of the world's major governments!

One very positive result of "gigantism" has been a partial change in mission orientation. Early investigators had concentrated upon the launch phase and the arrival at the 550-AU solar gravitational focus decades later. More recently, creative ideas have emerged about unique measurements that could be performed during the decades-long interstellar cruise phase.

One of the most interesting of these proposals was discussed by Cornell astronomer Jeffrey Van Cleve at the August 1994 New York University/United Nations conference on robotic interstellar travel. Van Cleve, who specializes in the infrared imaging of infant solar systems using the Mount Palomar telescope, suggests that an extrasolar probe could look back at the Solar System from a distance of a few hundred AU. The resulting infrared imagery of an existing solar system could provide a "truth test" for interpretations of imagery of suspected more distant solar systems.

Because of the very small solar disc beyond the 550 AU focus, a random trajectory orientation would result in very few objects occulted at any one time. Some form of mid-course correction capability would be a good idea—be it chemical or ion thrusters or something more exotic.

A developing debate among project supporters is concerned with the best aim direction for a Focal probe. Astrophysicists are drawn to the ASTROsail concept, in which the trajectory direction is opposite a mysterious radiating object such as the galactic center. We may actually be able, using the projected technology of the Focal probe, to image the event horizon of the massive black hole that may be at the center of the Milky Way Galaxy, in the constellation Sagittarius.

SETI researchers, such as John Heidmann of Paris Observatory, would choose the trajectory direction carefully to optimize the chances that a star with an advanced civilization would be occulted by the Sun. Such a SETIsail would therefore be directed along the Galaxy's spiral arms.

Because of the new interest in extrasolar probing and the expanding scientific payload projections, we might consider launching a series of extrasolar sailing probes rather than just one. Giovanni Vulpetti of Telespazio in Rome proposes to first launch a test

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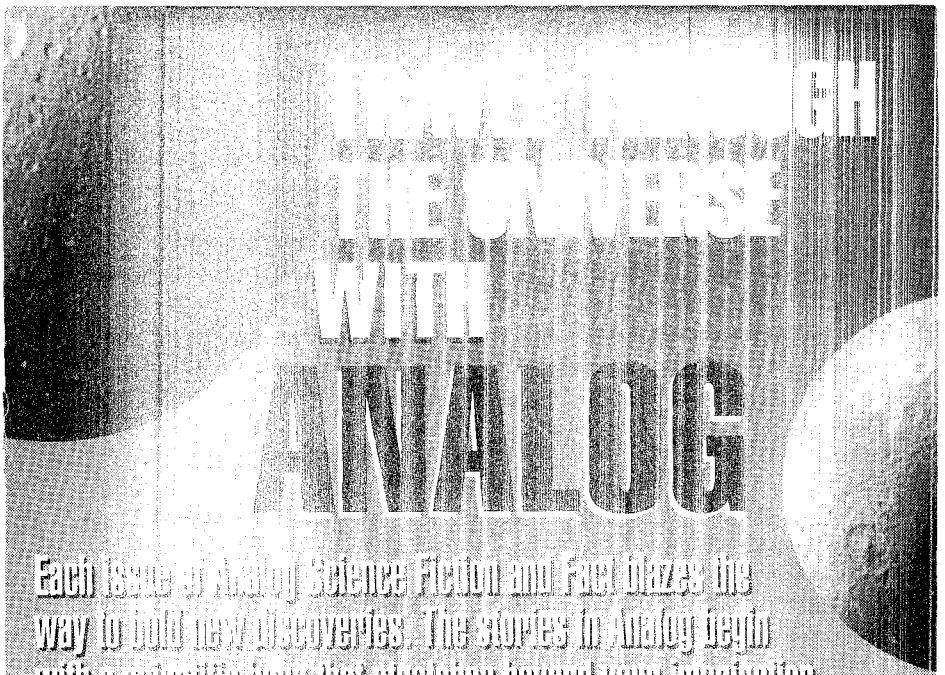

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sail to 100-200 AU, to be called Project Aurora. After the successful conclusion of this mission the Focal missions SETIsail and ASTROsail would be launched. (If Focal is considered an interstellar-precursor mission, would Aurora be called an "interstellar-precursor-precursor"?)

Conclusion: The Mission Profile

Although many of the details remain to be worked out, we can now outline the basic steps of an early extrasolar sailing mission. Imagine that it is sometime in the first quarter of the 21st century, and the rocket carrying the sail and payload has entered LEO. The one-micron thick sail is safely stowed in the carrier rocket, as is the 25-50 kg scientific payload.

After checkout in its parking orbit, the craft is propelled into higher orbit. This would probably be done using a small conventional rocket, although partial sail unfurlment early in the mission remains an option. The craft would then be maneuvered towards escape velocity from the Earth-Moon system, perhaps flying one of the low-energy chaotic or "fuzzy boundary" trajectories investigated by Edward Belbruno and first applied to the 1991 Japanese Moon probe Hiten.

After escaping the gravitational influence of the Earth and Moon, the craft might use repeated gravity assists of Earth and Venus (as did the *Galileo* Jupiter probe) to enter a near-parabolic solar orbit with a perihelion within the orbit of Mercury. At perihelion, the sail is fully unfurled (or inflated, if a Quasat-like sail is used), with its most reflective surface oriented towards the Sun. The craft begins to spiral outward, with an acceleration of a few thousandths of an Earth surface gravity.

The acceleration is modest enough that massive cables and supporting structure are not needed. High tensile-strength, low-mass material such as silicon carbide provides the cables and structure required.

Soon, the spacecraft has reached its terminal velocity. If vectored towards a near-ecliptic trajectory, it might first perform a close flyby of Jupiter to pick up a bit more velocity from the giant planet.

Moving beyond the planets, the probe instruments begin to survey particle and field levels and perform astronomical measurements of our Solar System and more remote targets. The decades pass as the routine of monitoring the extrasolar probe begins to become monotonous.

Finally, the craft is 550 AU from the Sun. The reflector is now aligned to collect greatly amplified signals from objects occulted by the Sun. The first data is collected and transmitted towards the Earth. When the signals arrive at Earth-bound radio telescopes three days later, our view of the Universe will begin to change radically.

We cannot say, of course, what galactic information will be broadcast towards us from this probe in the depths of space. But it is quite possible that the results of our first true extrasolar probe might begin our transformation into a galactic species. ■

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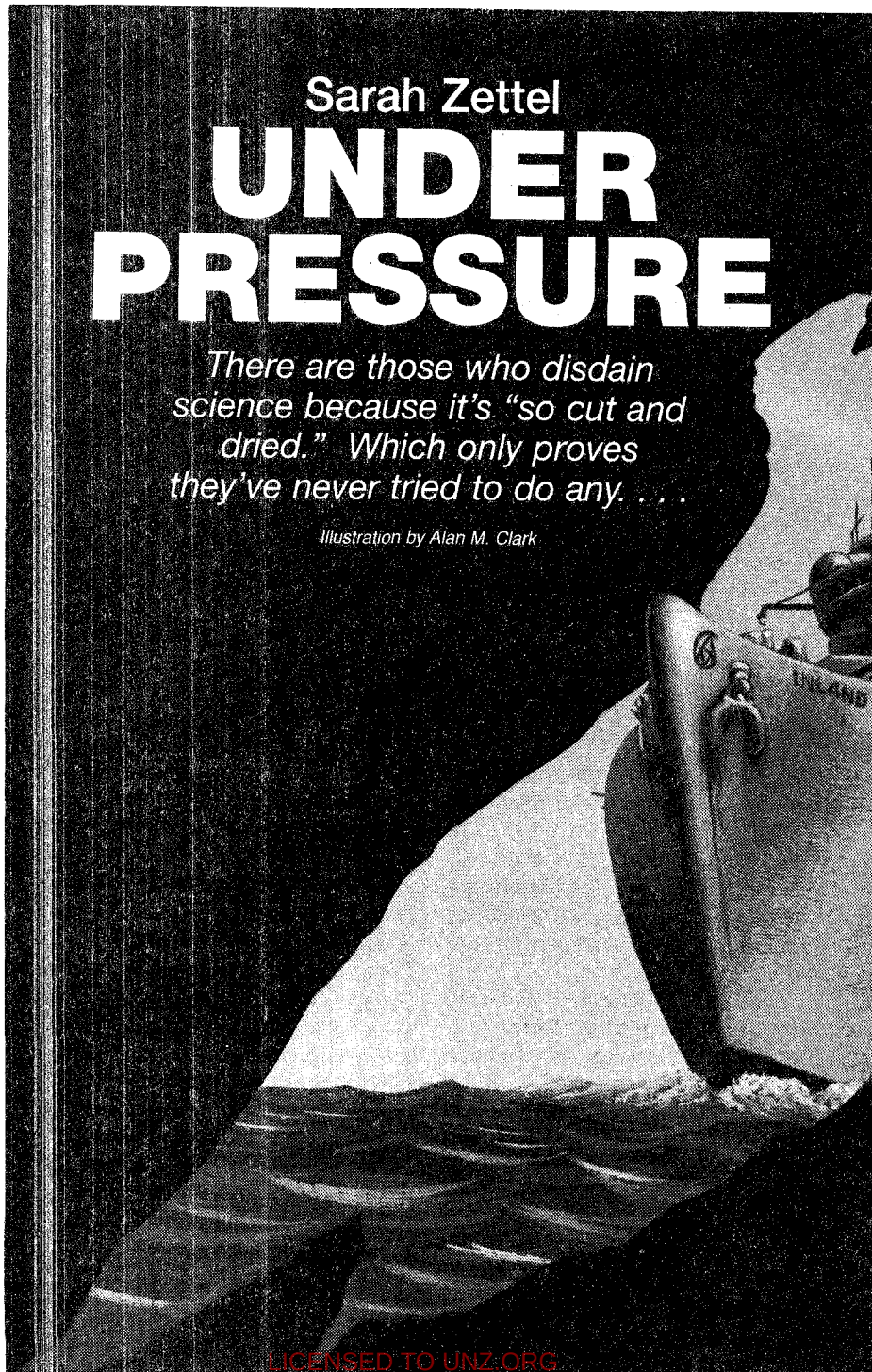
Sarah Zettel

UNDER PRESSURE

There are those who disdain science because it's "so cut and dried." Which only proves they've never tried to do any. . . .

Illustration by Alan M. Clark



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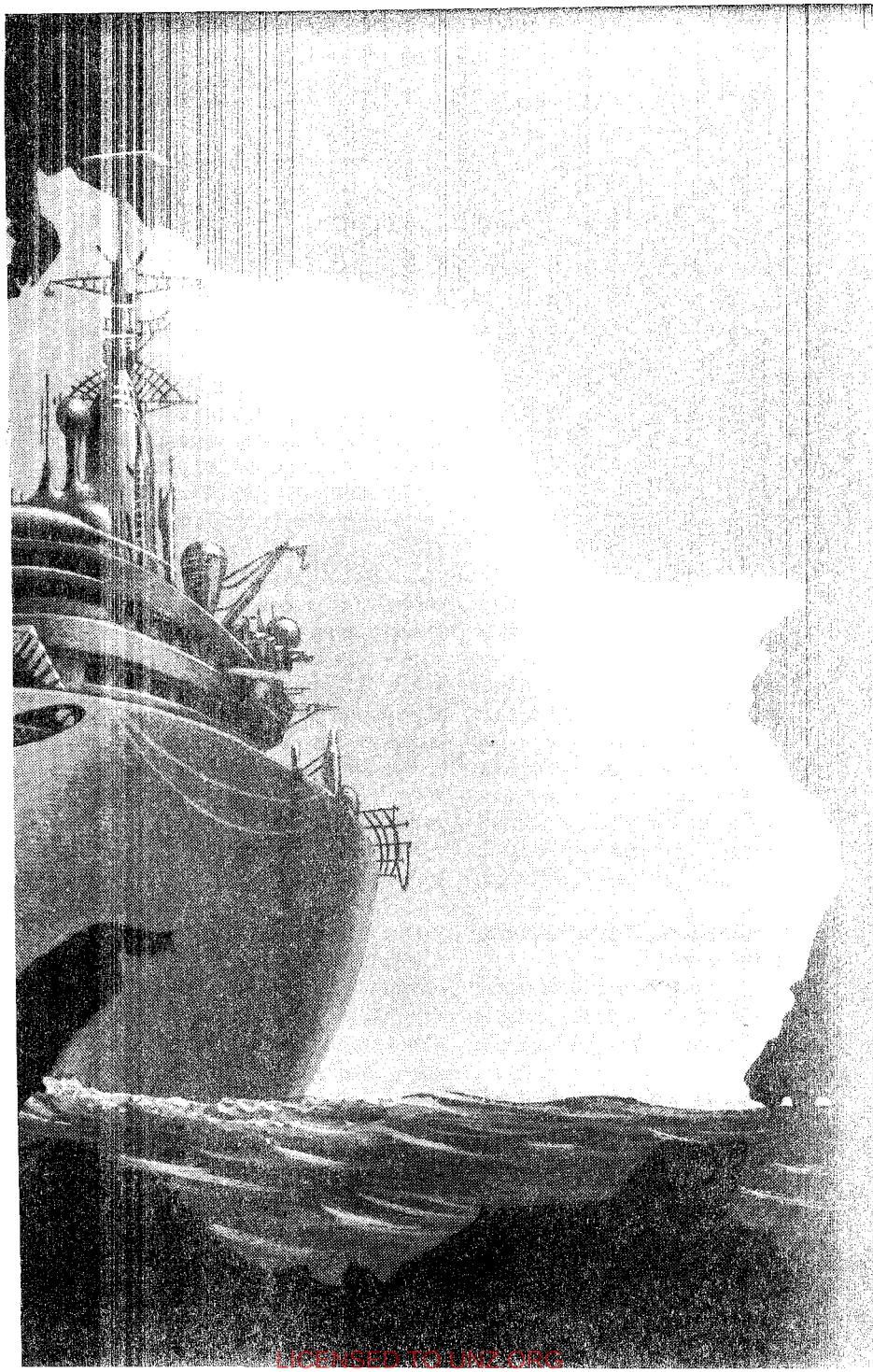

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"ED!"

Ed Nickerson barely heard Marcy's voice over the riot of the waves and the frigid autumn wind. He squinted towards the bow of the ship. Marcy stood up front of the mast, gripping the railing with one hand and pointing out across the rolling, grey water.

Ed's gaze followed the line of her arm and settled on the sick, white blur spread across Lake Superior's surface. A flock of seagulls wheeled overhead, screeching at each other and the world in general.

"I see it!" he shouted back, and a cold that had nothing to do with the weather settled around him.

Ed trudged forward to join Marcy and Doug, his other graduate student, up front of the mast. He reached them just as the prow of the *Inland Sea* sliced through the mass of dead fish.

There were so many of them, they flattened Superior's restless waves. The corpses collided with the hull, making dull thumping noises. Ed's jaw clenched as he watched the screaming, diving scavenger birds cluster around to take their share of the carnage.

Finally, Ed sighed. "Take a water sample, get the nets and—"

"Start hauling them up for tissue samples. Log them, ice them, and give you the data sheet," Marcy finished for him.

"So much for the old wheeze about the lake that never gives up her dead," added Doug.

When Ed didn't respond to the quip, Doug and Marcy glanced at each other and retreated to the equipment locker.

Ed slumped against the rail and stared across the lake. They'd sailed far enough out that there was no land; just rolling, grey, fresh water under an October sky heavy with clouds. He scowled at the bickering gulls. They knew they needed to hurry. Lake Superior wouldn't keep this display out for long.

There really was a reason the lake had its reputation for never giving up the dead. Superior was so cold that it acted like a refrigerator, preventing the decay of organic materials. Without decay, none of the gases that would normally keep a body afloat were generated. Superior would soon take these fish, as it took the bodies of the men on the *Edmund Fitzgerald* and all the other doomed lakers, straight down to the silt and rock bottom a mile below, and keep them there. The hopes the Waterways Restoration Project cherished for the lake would go right down with them.

What're you doing? He demanded silently of the icy water. *We're trying to help this time!*

Ed had been recruited by the project twenty years ago, when he'd had more hair and fewer hopes. Up to that point, his career as a limnology professor had consisted of writing articles in obscure publications, and a lot of what his father called "mucking about on the lakes." The "mucking about" had mostly involved shepherding graduate students out onto Lake Superior to watch the aquaculture slowly die from invading species and human contamination.

Then the Waterways Restoration Project had asked him to come down

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to Detroit. He sat on a sagging sofa in the project office with his blossoming cynicism and a mug of coffee, listening to Dr. Jerry Van de Carr and Danette Washington rhapsodize about their new plan.

"You're going to use the Great Lakes as a test case?" Incredulity had wrinkled Ed's forehead. "The five biggest bodies of fresh water on the planet as a *test?*" He set the chipped mug down. "You federal types don't do anything by halves, do you?"

"It's not as crazy as it sounds, Ed." Danette was a specialist in urban waterways as well as an old friend: If it hurt Ed to see what was happening up around Lake Superior and Lake Huron, he couldn't imagine what she felt like studying the Detroit river. "The Great Lakes are big, yes, but they're manageable. Look at Erie. The whole lake was brought back to life just by controlling the phosphorus content."

"And it's not exactly a test." Van de Carr's hand kept straying to his tie. "Right now the Europeans are breathing life back into the Caspian Sea, and the Thames, and you know what an appalling mess both those are."

"Yeah." Ed found his interest rising cautiously to the surface.

Van de Carr straightened the knot on his tie minutely. "It's all information flow, Dr. Nickerson. You determine what conditions are and start changing them to what you want them to be. You relocate the invaders back to their own environments. You breed the natives by the tank load and turn them loose. You create some designer proteins to break down the waste and the pollutants—"

"Hold it!" Ed waved his hands and made the "time-out" sign. "Where do 'you' get the money for this fantasy?"

"From us." Danette grinned at him. "We're part of the Environmental Jobs Initiative. Don't you watch the news?"

Ed shook his head. "I've got my own list of things to be depressed about. I don't need CNN adding to it."

"It's a whole new industry, Dr. Nickerson." Jerry's voice began to rise. "The Green Revolution's happening. Think about it!" Ed watched the look in the other man's eyes drift further away, as if he were seeing straight through the plaster walls towards the Great Lakes, or a set of video cameras. "Rivers you can swim in, in the middle of cities! Lakes you can fish in and not have to worry about what you catch, either in terms of poison or quantity. Clean water. Really clean, fresh water for Mother Nature and for us."

"And jobs." Danette brought Ed's attention back to her. "Real, honest-to-God, steady, good-paying jobs. You don't need a Ph.D. to crew a ship or a fish farm, and there'll be a mountain of construction work and data entry to be done."

Ed opened his mouth but Danette cut him off. "It is too going to turn a profit. Soon as the basic resuscitation's done, we're going to put the waterways back to work. When the new gas taxes get put in, it's suddenly going to get real cheap to ship raw materials using electric motors. Did you know that you can breed fresh water algae that'll feed cattle? And did you know you can—"

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Ed threw back his head and laughed. "OK, OK, Danette. You got me. What do we do first?"

Van de Carr's sagging face relaxed into a smile. "First we get you a title and a paycheck. Then we pick your brains about the lakes. Then we get to work."

So, Ed joined the revolution and found out it demanded hard work through late nights. In the early days, Ed spent as much time in Washington and Lansing arguing for funding as he did on the lakes with his students and co-workers sinking the computer sampling stations they had nicknamed "spy-buoys." He worked in Ontario and Quebec for months at a time. The Canadians were a decade ahead of the U.S. when it came to cleaning up the lakes and the acid rains. Ed shamelessly bribed a flock of their experts to come south for the winter.

Then came the miracle. The fish hatcheries hooked up with a firm of genetic engineers to design a symbiote that could be bred to work inside the fish they were reintroducing into the lakes. The symbiote, named TDS by the PR team, would break down any toxins swallowed by its host organism, leaving only harmless proteins to pass through the digestive tract. With the announcement that the symbiote was viable, the project found a new obstacle in the form of the FDA. It'd been Jerry's relentless shouting and string-pulling that finally mowed them down.

After that, the project took off like a rocket. Ed watched Danette's predictions come true as well as Jerry's. The ships did come back to the lakes. Maybe the re-fitted barges carrying garbage to and from the recycling centers didn't have the ambience of the timber and iron-ore vessels of the previous century, but they were cleaner, quieter, and almost as profitable.

Then the fish started dying.

"Ed?"

Ed shook himself and looked up at Nelson Renier. It was a long way up, too. The captain had developed a permanent slouch to cope with cramped pilot houses and a willfully deaf ear to cope with jokes about being a sailor named Nelson.

"Yeah?"

"Weather service says we got a squall coming down. We'd better head back in."

Ed pushed himself away from the rail. "Some days, Nels, I think it'd be better if we never went out."

The captain dug his hands into the pockets of his Thinsulate anorak. "I'm telling you, you federal types are never going to get Superior to play nice."

"I'm not a federal type," muttered Ed.

Nels shrugged. "Whatever you say, Ed. But the lake's still the enemy. Back in the sixties, my granddad lost two fifteen-thousand ton ships right out from under him. He used to say Superior was just waiting for a chance to do it to you, whoever you were."

Ed mustered a brisk tone. "I'm going down to see what the kids're doing. Let me know when we're in." Balancing carefully so he didn't need to lean against the rail, he made his way along the deck.

Ed descended the metal ladder to

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the tiny laboratory cabin and slid the door back.

Once upon a time, Ed had believed that laboratories were serious, orderly places, full of white-coated inhabitants speaking in a language comprised entirely of six-syllable words. Somewhere that might be true, but not aboard the *Inland Sea*. The lab was a crowded room with the counter-top equipment wedged into place by textbooks and reference manuals to keep it from rattling around. Only the glassware was consistently stored in its cabinets. Over the sink, one of his early students had hung the sign "This is a lab sink, not a kitchen sink. Leave dishes and die!"

As Ed pushed open the door, Doug was distributing his tissue samples into petri dishes by pouring them out of a Waring blender. Marcy, busy over her test tube rack, turned around briefly and said, "Pass me the hand thingy, will you?"

Obligingly, Doug tossed her the miniscanner.

"Anything new?" Ed braced himself in the threshold.

"Not yet." Marcy scribbled a number on the corked sample tube full of clear lake water and then ran the scanner over the label to record its information in her sketchpad computer. "I'd like to get some algae samples, though."

Ed shook his head. "Squall's coming. We can put out a net, or you can call the spy-buoy when we get in."

"OK," she agreed reluctantly. "Maybe I can ask it where the EK 96 algae strain's gotten itself to."

"And while you're at it, ask it how come we're getting consisently low fat tissue readings from these fish." Doug yanked open the drawer to find an extra roll of sticky labels.

"What've you found?" Ed demanded.

"Nothing!" Doug slammed the drawer shut again. "Same old song. All the fish we've gotten samples from in the past three months have a lower than average proportion of fat cells."

"Are you saying you're going with the theory they've been noising around on the south shore? That the fish are starving to death?" Ed felt his brow furrow.

"I wish it was that obvious." Doug jammed his pencil down so hard onto the label the tip snapped off. "All the fish we've sampled, here and on the shore stations, have had full stomachs. If I was going to guess about what got this last school, I'd say they died of cold."

Marcy's busy hands froze. "Lake Superior whitefish?"

"Look, they haven't got enough fat in their bodies, that means they're going to be susceptible to the cold, and disease, and bacteria and—"

"There are no abnormal bacterial levels in them, Doug, or in the water around them. There is nothing in that water that hasn't either been there for hundreds of years, or that we haven't grown and catalogued. I've checked." She tapped her sketchpad meaningfully.

"Which leaves cold." Doug scraped the broken point of the pencil across the label and scowled at the result.

"Reality call for Doug." Marcy held

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up an imaginary telephone receiver. "The whitefish are bred to thrive in the cold!"

Slowly, Doug set down the pencil and the roll of labels. "Then you tell me what's doing it," he said. "What is killing them without leaving a trace? These damned fish are perfectly bred, perfectly adapted, and perfectly dead."

A series of low chimes sounded through the lab, cutting off what could have worked itself into a serious blowup. As it was, Marcy and Doug kept glowering at each other while Ed flipped back the cover on one of the spare sketchpads and plugged the cable into the nearest phone jack.

"Nickerson," he said succinctly as the machine powered up and the screen cleared.

Danette grinned at him from the other side. "Hello, Stranger."

"Danni!" Ed was one of the three people living who had permission to use her nickname. "Where are you?" The range for the communications facilities on the *Inland Sea* didn't extend past the Mackinac bridge, never mind all the way down to Detroit.

"Your office," she told him. "I didn't think you'd mind, and you haven't changed your pass code in three years." She leaned forward, suddenly serious. "Have you found anything new out there, Ed?"

"Another school of dead fish and a missing strain of algae." He sighed and flicked a glance at his students. They were both bent over their samples, studiously pretending not to listen. "The grads are working up some ideas that might get us somewhere, but we're not there yet."

Danette began to chew her lower lip.

"What's happened?" Even as he asked, Ed wasn't sure he wanted to know the answer.

Danette's gaze shifted to the right, and then to the left, as if she were checking to make sure no one was looking over her shoulders. "Jerry's reasoning powers have crashed."

"What?"

She sighed. "Our project director has decided that the TDS symbiote is to blame for the fish dying off. He's been getting the lab to work up graphs showing a curve of unpredicted symbiote increase as related to the increased rate of die-offs. More symbiote per pound of fish, per sample of algae, that kind of thing. . . ." She cut herself off.

"Is there a real relationship?" Ed frowned.

Danette shook her head. "The average body weight on the fish is down and the concentration of symbiote in the wild is a lot higher than in the hatcheries. There's also a higher concentration of symbiote in the algae samples we've been taking than in the ones we've been breeding. So the relationship is real, but in context it doesn't *necessarily* mean what Jerry's making out. In fact, we don't have any idea what it really means. However, the symbiote is the one thing we've introduced on a big scale. The folks who designed it all work for En-Gene, not the project. Jerry's going to use the numbers to make Judas goats out of them."

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"Lies, damn lies and statistics," muttered Ed.

"You got that right." Danette's shoulders sagged. "The problem is, Jerry's worked himself up into believing it. He's jacked into the fact that I won't buy it, so he won't even open his door for me. I was hoping you could get him talking again. If we can get even a little advance warning on just how bleak he's going to paint things tomorrow, maybe we can haul together some counterarguments."

"We're on our way back in now, Danni. We should be there in a couple of hours."

"I'll be waiting. And Ed, if you think of anything brilliant on the way in. . . ."

"I'll try, Danni. I'll try."

They said goodbye and shut the connection down. Ed turned around. Doug and Marcy were staring at him, hands dangling at their sides.

"Well, now you know," he said. "We're in for it, unless we find out what's really happening out here." He turned to Marcy. "What were you saying about the EK 96 algae strain?"

She swallowed hard. "It's one of the transitional strains we let loose last spring to help keep the change from toxic-water species to clean-water species gradual. It proliferated beautifully over the spring, everything right on schedule. Now I can't find it anywhere." She swept her hand out to encompass her entire rack of neatly labeled test tubes. "It's not in the fish. It's not in the water. It's vanished over the summer—and it was bred for cold too," she added with a meaningful glance towards Doug. "None of this makes any sense."

Ed sighed. "All right. Put everything away. You are both going to your rooms. We'll be back in a couple of hours. I don't want either of you back in a lab until tomorrow morning at the earliest. Fresh day, fresh brains."

Doug and Marcy rolled their eyes at each other but complied. Under his gaze, the pair of them cleaned their workstations, labeled their remaining samples, and left, without saying another word. He heard two cabin doors slam and allowed himself a small smile. They would be in their separate rooms with their separate computers going over all the available information about the crisis. They were dedicated, those two. It was the criterion he used to pick the students he took into the field.

Ed turned around and surveyed the empty lab. Doug's words still hung in the air. Perfectly bred, perfectly adapted, and perfectly dead.

Memories. . . .

"Mother Nature has taken care of the groundwork." Jerry led Ed and Danette along the pier to the expanse of the breeding pens, netted enclosures that stretched out into the Lake Erie waters. "We're just using the food chain to take care of the problems we introduced into it."

"By creating a bug that eats pesticides." Ed surveyed the tidy square beds of algae.

"It's not a bug and it doesn't eat anything." Danette elbowed his arm. "It's a tailored symbiote that breaks down the contaminants into harmless constituents."

"Tailored Digestive Symbiote," Jerry said. "TDS. 'Teds' to the media. The

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PR team figured it was important to have a friendly-sounding acronym."

Ed wondered how long Jerry had worked on making it sound like he had nothing to do with that particular team. He might even have thought up the acronym himself.

"We're using it in a sort of pincer maneuver," Jerry went on. "We introduce one strain into the algae at the bottom of the chain, and another into the fish at the top of the chain. There's going to be a dip in the invertebrate population when they start ingesting algae with higher than normal concentrations of contaminants, but that'll level off as the water cleans up. The fish will have the symbiote in their intestinal tracts. They'll swallow the poison, dioxin, or DDT, or whatever, the symbiote will snatch it up. Then, TDS breaks the poison down into a set of basic proteins and discards it back into the digestive tract. Anything the fish can't use is discarded back into the water. Anything that isn't broken down the first time gets reabsorbed into the system for another go-around. Poof!" Jerry grinned. "Live fish and clean water."

"It's going to be in the algae too, you said." Danette frowned at the pens. "What happens when there's no more poison for the algae to absorb?" Danette seemed a little reluctant to ask the question, but Ed was glad she did.

"The tailored algae die off and the native species take their place. Competition's pretty fierce down at that level. The lab staff figures it'll take about ten years to clear out Erie and Ontario, but more like twenty for Superior."

Ed felt his back stiffen.

Twenty for Superior. It's been close to twenty years since the symbiote was introduced.

No. That didn't make sense. If the die-offs of the tailored algae were causing the problem, it would have manifested itself years ago in the smaller lakes. The project had monitored the die-offs carefully, the way they monitored everything. The native species of algae had filled the empty niches right on cue. The insect population had stayed perfectly stable, and the fish had gone right on swimming. Everywhere but in Superior, the biggest of the Great Lakes, and the top of the Great Lakes's own chain, but so far, the smaller lakes were untainted. All the water was checked as it flowed down to the smaller lakes. Checked, cross-checked and measured. How could even a teaspoon of unwanted material have gotten past the spy-buoys?

And how does Marcy's lost strain fit in? Ed rubbed his forehead. *I'm missing something and it's something obvious—I'm going to kick myself when I find it.* Ed felt a slow grin spread across his face. *Listen to me. The south shore's teeming with Nobel Prize level biologists, and I think I'm going to find the answer just because I get out here and get my feet wet.* He tapped his square calloused finger against the countertop and tried not to remember the certainty in Nelson's voice as he talked about the lake.

Ed was still sitting in the empty lab when he heard Nelson bellowing a

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greeting to the crewmen on the docks. He waited until the clatter of Doug and Marcy emerging from their cabins had passed before climbing out onto deck himself.

He was stretching his back and watching his students climb down the ladder to the pier when a familiar figure came strolling up to the ship.

"Danette!" His students cleared the way for Ed to clamber down to her.

"Ahoy!" She laughed and waved. "Welcome back."

"Thanks." He gave her a brief but warm hug. Marcy and Doug joined them on the dock. "Danette Washington, meet my assistants." He performed the introductions between her and his students. "I was just getting ready to send them to bed without supper." He gave Marcy and Doug a broad wink. They grinned at each other, and Ed felt better knowing their senses of humor seemed to have been restored.

"So, where're you staying?" Ed offered her his arm with exaggerated gallantry. She took it with an easy smile and together they strolled towards the station. Ed felt his heart beat slow and heavy as the warmth of her hand began to soak through his sleeve. Unbidden, the memory of their brief attempt at a love affair washed back over him from a time he considered ancient history.

All that time had not diminished Danette's enthusiasm for her work, nor her ability to lift his spirits. While they walked, it became clear that Danette considered Jerry Van de Carr office-only talk. Instead, she kept up a stream of chatter about the current state of the Detroit River clean-up, the politicians involved, the endless contract negotiations, and how they had determined the human skull a trawler had uprooted was not Jimmy Hoffa, but it could be Elvis.

Monitor Station No. 67 was a low concrete building on the shore, painted what Danette referred to as "industrial white." Ed unlocked his office and flicked on the light switch. The computer on the desk beeped urgently as its power came on with the lights.

" 'Scuse me, Danni." Ed motioned her to one of the spare chairs.

"Bet you next month's pay it's Jerry," she said. "I should get out of here." She ducked back into the hall. "Jesus, who'd've ever thought the Green Revolution'd make me go cloak-and-dagger." She shut the door behind her.

Ed touched the PHONE button on the keyboard. The wall screen lit up and Jerry looked down on him with tired eyes.

"Ed." He adjusted his tie. "Glad you're here."

Try again, Jerry, Ed thought, as he fumbled for an innocuous opening.

"Hi, Jerry." His voice sounded wooden in his own ears. Ed hoped Jerry wouldn't notice. "I was just going to call in. I was on the line with Dr. Washington today, she said there's a problem—"

"Problem." Jerry snorted. "Yeah, there's a problem. The project was lied to, that's the problem."

"By who?" asked Ed guardedly. Part of him was already braced for the outburst.

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Surprisingly, it didn't come. "En-Gene Labs," said Jerry quietly. "I got a gigabyte worth of files on them. Their trials on the TDS symbiote weren't done in conditions even close to what it'd be operating under out in the wild."

"And they got past the FDA and Health and Human Services anyway?" Ed asked out loud. Inside he thought, *How far are you going to take this, Jerry?*

"You're forgetting how new all this was twenty years ago, Ed. Everything was being reviewed on a case-by-case basis by people who didn't have the vaguest idea what was really going on. I've got the new work-ups from a dozen experts. The symbiote has invaded the digestive system of the fish at unpredicted levels and is interfering with the fish's ability to digest food. They're starving to death."

With full stomachs. Ed remembered Doug and Marcy's near-argument on the boat. Jerry's thumbnail sketch fit the facts neatly. Danni wasn't buying it, though, and that was no small fact in and of itself.

"Experts spend a lot of time disagreeing, Jerry. Have you got outside confirmation on the data?"

"Our reports have been prepared by the best people we've got." *Which means no,* thought Ed, while Jerry kept right on talking. "The data's all there."

Which means outside sources were not going to be called in. Ed rubbed his eyes. "What's the rush, Jerry? We may have turned up something fresh this trip out. Whatever the problem is, it's isolated in Superior. . . ."

Jerry shook his head. "But we can't guarantee that it's going to stay isolated. En-Gene may have unleashed a major biohazard here. That's the angle the news wires are playing for. You wouldn't believe the screaming going on down in Washington."

"Yeah, I would. I've been to a few of those committee meetings myself, remember?" Ed sighed. His shoes and shirt were still wet from being out on the lake and the chill was seeping through his to skin. "So, the only way we've got to deal with this is to denounce the effort that's had more to do with our success than anything else and throw En-Gene to the wolves?"

"That's it, Ed." Jerry fingered the knot on his tie. "But, if we act fast, the main project will get out with a whole skin."

"Then what?" Ed wanted to slump into his chair, but in his unventilated office, the upholstery would stay wet for days.

"Then we look for another way to clean this place up," Jerry said to his desktop. "Maybe we'll even find one."

Ed found a moment to pity Jerry. He'd been the one who believed in the revolution before it even happened. He'd sold his soul for it, a piece at a time. Now that the real trouble had come, he had none left to shore himself up with. The project had become more important than its goals. Knowing why Jerry was doing this though, did nothing to warm Ed's chill.

"When's the axe fall?" Ed didn't feel up to being diplomatic.

"Tomorrow, two o'clock." Jerry

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straightened his shoulders and marshalled his best sincere expression. "This is not the fault of anyone in the project, Ed, I'm going to make that perfectly clear."

"I'm sure." Ed let his hand drop onto the BREAK key and the screen faded to black. He stared bleakly at the blank screen for a moment, then went to look for Danette.

He found her in the lobby, typing furiously on her sketchpad, which was jacked into one of the spare outside lines.

"You getting any help?" Ed asked.

"Not really." Her attention stayed on the screen and he saw the lines strain was drawing on her face. The symbiote was what had made the Detroit river cleanup even thinkable. If it was taken out of the project, Ed still had a fairly clean lake. Danette had a ruined promise and a twenty-year setback.

"The word's gone around about what Jerry's got planned for tomorrow," Danni said. "The whole crowd seems to have decided it's everybody for themselves." She looked up and her smile was tight and mirthless. "How went your part of the war?"

"You were right, Danni, he's lost his mind." Ed shivered. "He really thinks he can send En-Gene down without taking us along for the ride." He rubbed his arms. "Listen, since we seem to be the condemned, you want to have a hearty meal? I've got this pot of stew. . . ."

Danni's expression relaxed into a real smile. "I've missed your cooking."

"And who knows?" Ed tried to sound cheerful. "We've still got what, fifteen hours? We still might figure out something."

"You mean your students might." Danni snapped her sketchpad's case closed. "You know they've both barricaded themselves in the lab, don't you?"

I knew they'd mutiny. Ed smiled.

"That, my dear Danette, is what God made grad students for." He slid a solicitous hand under her elbow and helped raise her to her feet. "Shall we leave them to it?"

The look she gave him said she knew how much worry he was covering up, but she let it go.

It wasn't until they were both comfortably stowed at Ed's dining room table, working on plates of stew and biscuits, that Danette raised the subject of the project again. She did it without preamble or transition, so Ed knew he'd been right. She hadn't stopped thinking about it any more than he had.

"I don't understand why this is happening to Superior," Danni said, reaching for the butter. "The rivers are all fine, and the Caspian Sea, and the Black Sea."

"So far." Ed stared out the window. The wind was picking up as the twilight deepened. The roof shingles started to rattle in response. Ed gauged the noise. More than a few would be gone by morning. "That's what worries me, Danni. We're not the oldest project, but we've made more progress in the Great Lakes than anywhere else."

"That's because you didn't have as far to go. There was no nuclear waste

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at all here, and relatively little hard garbage to dig up, and we did catch the road salt problem before it went too far."

The first drops of rain spattered against the window. "Before it went too far." Ed poked his fork aimlessly into the remains of his dinner. "So, the question is now, did we go too far or not far enough?"

For the first time, Danette's dark eyes looked really tired. "I wish I knew, Ed. I get worried. We are the children of the information age. We can find out anything, right? We've got all this data stored on chips and sorted into neat little packages. But that's not how reality is, is it? The world outside those packages is so . . ." she laced her fingers together ". . . interconnected. I keep wondering if we've missed a combination somewhere."

She rested her elbows on the table and stared down at her half-empty plate. "Remember how they discovered that the chemicals used in the initial paper recycling programs were more hazardous to the environment than the chemicals used to make new Styrofoam? How long did it take to get that changed around?"

"Years. Every time someone tried to say something bad about recycling, the Greens had a fit." Ed dropped his fork and pushed his plate away. "The Greens and Jerry."

Danette brushed a shower of crumbs onto the floor. "A revolution needs fanatics, Ed."

"Maybe. Maybe. But fanatics don't think things through, Danni."

"So here we sit, a pair of old fools." She reached out and squeezed his hand. "Wondering if we've been blinded by good intentions and pretty dreams."

Ed held still, trying to drink in strength from her touch and almost succeeding.

Outside, the squall was really kicking up its heels. The rain drops had turned into solid sheets of water slapping against the house. The roof and walls creaked with long, complaining sounds. Inside him, Ed felt other walls begin to strain against a storm made of nothing but emotions.

He shoved his chair back and lifted his hand out from under Danette's so he could walk to the windows. Watching the curtains of rain ripple in the sparse street light was easier than watching his reflection in her eyes.

"The deadly waters roll. . . ." he murmured the words to an old lake song as a fresh wave of rain smacked against the windows.

Behind him, Danni sighed. "But the waters aren't deadly anymore, Ed. We took care of that. No pesticides, no road salt, no acid rain. . . ."

Ed turned slowly around.

"My God," he whispered. "The waters!" Before he knew what he was doing, he snatched the car keys off their hook and ran out into the rain, barely aware of Danette matching his stride.

It was a bad night to be driving too fast and Ed almost put them in the ditch a half dozen times before they'd gone three miles.

"You want to tell me what's going on?" Even in the dim light, he could see how white Danette's knuckles

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were where she clutched the dash. He didn't take his foot off the accelerator.

"What's going on is we've been idiots. With Jerry's legacy of graphs and biological magnifying glasses, we've forgotten that Nature has its own agenda." He skidded into the station's parking lot, raising a spray of water under the tires. "Nelson was right. The lake was waiting for its chance to do it to us."

"Ed. . . ."

"Danette, the algae isn't the bottom of the chain in the lakes. The water is. The one factor in the equation we have completely changed is the water. All of it. The lake water, the sea water and the rain water."

Danette's eyes widened and Ed knew he didn't have to say another word. They dove across the parking lot hanging onto each other to keep their balance on the slick pavement. Danni caught Ed's key card as it slipped from his fingers and shoved it into the reader. The door latch clicked open and they dashed side-by-side for the lab.

"What the—" demanded Doug and Marcy in a perfect chorus as Ed and Danette burst into the lab. The students were both bent over microscopes, each with one hand hovering over their keyboards.

"How do you get the weather service up on this thing?" Danni plunked herself down in front of the phone board. "We need to know where this squall is coming from."

"Doug, lend her a hand. Marcy, grab these." Ed hauled open one of the cabinets and began loading beakers into Marcy's arms. "Come on." He scooped up three more beakers and headed for the door.

"Watch the water." He was grateful for his own sealegs as he duck-walked over the puddles he and Danette left on the floor.

"Ed, if it's not too much trouble. . . ." Marcy's shoes squeaked loudly on the tiles as she struggled to keep up with him. "What are we doing?"

"Getting a sample. It's got to be clean or I would've used a bucket at home." Ed shoved the outside door open with his shoulder. A fresh load of rain soaked him to the skin all over again.

Marcy, to her credit, followed him out into the storm without hesitation. The rain plastered her hair to her scalp in an instant. Ed set his beakers down on the sidewalk and then took hers to set beside them.

"You're collecting the rain?" she said, bewildered.

"Right. The lake'll be there tomorrow. We can get a water sample and a fresh catch of fish as soon as the weather clears, but we need rainwater too." Ed kept his gaze on the beakers. The fat drops pinged and clattered onto the glass making a chaotic noise, like someone shaking a dozen jingle-bells.

"Come on, come on," he muttered as water began to collect inside the beakers.

"Ed." Marcy tapped him on the shoulder. "I know I'm supposed to play the dutiful protégé here, but, if you don't mind me asking—"

"Ed!"

Ed jerked his head around. Danni

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leaned half-way out of the station door. "We got it! The storm's coming in from across Quebec. I've got Doug downloading the weather patterns for the last two years. I could get to like this grad student thing!"

Ed grinned at her. "Make sure he gets the acid rain levels for that same time frame!"

"Excuse me!" shouted Marcy. "Why in God's name has my doctoral professor got me standing in the pouring rain?"

"Selection pressure." Ed squatted down and inspected the beakers. Three were almost a quarter of the way full.

"What?" The shrill note in Marcy's voice penetrated his attention all the way. Ed wiped at the water streaming down his cheeks and straightened up.

"That's what's killing the fish. That's where your algae went. Darwin took them out and Superior swallowed them."

"Dr. Nickerson—" began Marcy.

Ed picked up one of the beakers and squinted at the measurements. "I think we've got enough. Grab some, will you?" He wrapped his big hands around four of the beakers and carried them back towards the station. "And don't drip in them."

Marcy groaned, grabbed the remaining beakers and, holding her head carefully so her long hair dangled over one shoulder, followed him back into the lab.

"Dr. Washington. . . ." Marcy pleaded as they passed Danette.

Danette relieved Marcy of two of her beakers and fell into step beside her. "As soon as the TDS fish were released into Superior, natural selection started in on them. Survival of the fittest. The fittest being, among other things, the fish that were best able to convert the TDS algae into energy." She backed up against the lab's door and waited while Marcy went in first. "The same holds true for the algae. The fittest algae would be the algae that could convert the most dioxin into usable constituent chemicals without dying."

Marcy deposited the beakers on the lab counter. "So the populations of fish and algae that had the best connection with the symbiote would do the best, because their respective digestive systems would be able to filter more food out of the poison."

Marcy looked across to Doug who was still at the phone board. Doug shrugged at her and tossed a towel over the counter.

Marcy caught it and began rubbing her face dry. "I don't want to be rude, Dr. Washington, but we knew that." She toweled off the ends of her hair.

"Ah, but natural selection doesn't aim for 'the best.' " Ed began carefully pouring rainwater from the beaker into test tubes, ignoring the water running down the back of his neck and dripping from his jeans into his shoes. "It just aims for 'good enough,' and 'good enough' means good enough to produce babies under the existing environmental conditions. The species that has the most offspring that produce offspring, wins.

"Now." Ed shoved a rubber stopper into the test tube's mouth. "You just said that in Lake Superior, as it stood twenty years ago, the species that

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would have the most offspring would be the species with the most efficient link to the symbiote." He turned to both of the students. "But selection was also going on for the TDS symbiote. The symbiote variant that would be most successful would be the one with the healthiest hosts because healthier hosts would be more likely to breed, and pass more of the symbiote on to the next generation. So the variant that could seek and find the most toxins in the host system would be the winner. Now, where are toxins, dioxin specifically, held the longest in a living body?"

"Fatty tissues," said Doug promptly. "Oh my God. . . ."

Marcy's lips moved silently while she tried to work out what was coming next. "So when there wasn't enough toxin coming through the fish's digestive system from the lake water—"

"TDS, perfectly adapted to its environment, went after the one source of toxins it could get, which was the poison stored in the fish's fatty tissues. It went from being a symbiote to a parasite and started munching through the fish's body fat. Not enough body fat, and the fish become susceptible to cold.

"We were all right. The fish died of cold. Their condition was caused by the symbiote, and that lake did do it to us." Ed set the test tube in the rack. "Superior cleaned itself up faster than anywhere on Earth because the Canadians are ten years ahead of the rest of us in terms of acid rain clean-up. The rain water coming across Canada wasn't adding as much toxin to the system up here as the rain coming across the States. Add that to the fact that the organisms that died due to an increased intake of poison didn't decay and release the poison back into the system. They sank straight to the bottom and are lying around the wreck of the *Edmund Fitzgerald* in cold storage until erosion can do its thing. Even then, it's going to be another twenty years before that water circulates back up to where the TDS algae can have a crack at it. And if we want to run this all the way down to Lansing, we need to prove that all the water going into Superior is clean enough to tip the balance. Including the rain. Which is why we're all wringing wet and why we need those acidity reports." Ed raised his eyebrows meaningfully at Doug.

"It's downloading, it's downloading." Doug ran both hands through his hair. "Ed, if Dr. Van de Carr was going to say it was the symbiote killing the fish, is knowing why it's killing them really going to convince anybody that the project should be saved?"

Ed looked across at Danni. *Ah, the innocence of youth.*

"It's the difference between saying 'we don't know what's going on' and saying 'we've not only got an answer for you, we've got one we can do something about.' It'll mean Dr. Van de Carr can go into the committee with a solution found by program researchers."

Ed hunched over an imaginary desk-mounted microphone. "We at the Waterways Restoration Project are proud to announce that due to the diligence of our personnel, we have found the cause of the current bio-crisis in Lake

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Superior. Thanks to the rapid changeover to organic farming methods, a reduced level of toxins has been making its way into the lakes from the rain water, causing the TDS symbiote to suffer what amounts to malnutrition and become parasitic in nature. The solution to this problem lies in expanding and accelerating the transitional program which is already being geared up by our collaborators at En-Gene. In essence, ladies and gentleman, what has happened is that Mother Nature has bumped up our schedule." Ed gave a fair imitation of Jerry's hearty laugh.

"And pay attention to this, you two," Danette said. "It won't be the last time. All the time talking about the 'revolution' we forget we're not fighting a war, we're creating a system. We're never going to win this. We're going to have to monitor, analyze, correct and recorrect our actions from now 'til Kingdom Come. We're always going to have to be searching for a new balance."

"Which means we got job security," said Doug to Marcy. "My dad'll be thrilled anyway."

"It also means we'd better get the hand-thingy humming," Marcy climbed up on a high stool and reached down another rack of test tubes. "Then, what do you think? Maybe we can see about rerouting three or four of the freelance buoys down to the bottom of the lake. God alone knows what's going on down there."

Doug sighed. "Sleep is for the weak." He flipped open his sketchpad. "How far down is 93. . . ?"

Ed touched Danni's shoulder and very quietly, the two of them backed out the laboratory door.

"They'll get the numbers," said Ed. "We need to work out how you're going to present them to Van de Carr."

Danni raised her eyebrows and opened her mouth. Ed didn't even let her start. "You went out a lot further on this than I did, Danni. It's been my hope, but it's been your life. You should be the one to let those Lansing Land-Lubbers in on the reality call."

Danni's smile took on a softness Ed hadn't seen in years, but had never forgotten. She looked him straight in the eyes. "Do I take the good news home in person or over the lines?"

Ed took her hand. "Over the lines, I hope. We never really got to finish dinner, did we?"

"Ed, didn't you hear that lovely speech I made to your students? We're never finished." She squeezed his fingers gently. "We're always going to have to be searching for a new balance."

Ed slid his arm around her shoulders. "I've already found my new balance, Danni."

As she stood on tip-toe to kiss him, Ed knew she felt the same. ■

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Scott L. Towner

THE ENDLESS THROOP

Kelvin Throop is at it again. . . .

Stan,

I found these letters on my desk when I arrived at work this morning. Would you please tell Kelvin to drop things off during the day*—his erratic behavior tends to (understandably) scare the cleaning people.*

Scott

Dear Stan,

Thanks for forwarding all my fan mail, although I'm not sure "fan" is the correct word in some cases! Knowing that your Brass Tacks column is limited in size, I've answered only a *small* percentage of the letters you sent, and tried to keep my responses short. If you need to cut something out, please feel free—I hope I'll have many more opportunities in the future to show my face in your magazine. Ever since you told me that I wasn't cut out to be an editor, and to try my hand at writing, my life has changed for the better.

Speaking of which, I received your note (a month ago!) saying you were buying "Boisterous Buxom Boxing Bobcats," but I still haven't received any contracts for said story. . . . Lost in the mail, perhaps? Regardless, I would appreciate it if you could look into that for me. Call me a worrier, but this being only my third sale to you, I'm still pretty nervous. On a different note, I *loved* the art for "Redneck Aliens From the Dark Side of the Moon," and if I were richer (hint! hint!) I would buy it from the artist. Maybe I'll be able to afford it if the story wins the AnLab—on second thought, I'll just get someone to steal it. Why pay for what you can get for free?

The invitation to visit still stands—I know you and Joyce would love to take a dip in the hot springs out here, despite your skepticism. The springs are heated *naturally* in the deep bowels of the Earth—their temperature has nothing to do with the nuclear power plant nearby.

KELVIN THROOP

Dear *Analog:*

I have been a subscriber since the late 1930s, when John Campbell was editor, and this is the first time I've felt

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compelled to write.

My love for *Analog* stems from the fact that I've always viewed it as a bastion of ethics and morality against the ever more violent, chaotic, and amoral society we live in. Since I was a teenager, your stories have dazzled me with the technological and psychological advancements of mankind. I've read about how we might improve our lifestyles and create a safer environment, not to mention the possible consequences of sitting around and not doing anything about it. I've read about making peace with good aliens, and overcoming (somehow) the intentions of hostile aliens in an intelligent, rational manner. Don't think that stories like that didn't boost my morale when I was overseas during World War II! I kept my copies of *Astounding* right next to my weapon, whenever I could!

Despite all this, I was thrown for a loop when I read the filler by Kelvin Throop appearing in a recent issue. In case you don't remember, there were two quotes—the first from René Descartes, "I think, therefore I am," and the second from Kelvin Throop, Solipsist: "I think, therefore *you* are."

I've *barely* put up with Mr. Throop's presence in your magazine, figuring that *Analog,* like anything else, needs to change with the times. I realize that people are more tolerant nowadays of different philosophies on life, and God knows I've had to make a lot of adjustments as I've gotten older. I usually like those fillers and I learn something new every time I read one, but I can't believe you would actually promote solipsism!

Call me an old coot, but I think it was way out of line. We have enough people doing screwed up things—if you don't believe me, just pick up the newspaper! I would imagine an alien visiting our planet and observing what was going on here would think this was a maximum security prison without guards, or maybe an insane asylum. But I was so taken aback that something like this would appear in the same magazine that's seen me through five decades that I'm canceling my subscription.

ED WIN

Cobb County, GA

The author replies. . . .

Dear Mr. Win,

I'm not about to apologize for expressing my views of life, and as some guy who knew what he was talking about once said: "The Constitution gives you the right to be heard, but not taken seriously." Hopefully, that will give you something to think about! Oh, and here's another: "Everybody's entitled to his own ridiculous opinion."

Regardless of all this, however, your letter is only another one of the many obstacles that some cruel god is throwing at me, seeing that I am the only real person here. I will not yield, however—and one day, when all this is over and I've passed the Test, I will be elevated to a higher status and all you zombies will disappear like the illusions you are.

KELVIN THROOP

What's it to ya?, USA

Dear Mr. Throop,

I'd like you to know that you've

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done good for me. After reading your filler on solipsism, I've finally found the outlook I've needed for years. My life has purpose and meaning now. My vision is clear. Thank you so very much.

"ZEKE"

Michigan Militia

Dear Dr. Schmidt and Mr. Throop:

For a magazine that calls itself "hard" science fiction, I found "Redneck Aliens From the Dark Side of the Moon" (Late December, 1995) by Kelvin Throop to be the most laughable thing since the Twentieth Century Battery! I'm curious as to what Mr. Throop's background in science is, as well as your own, "Doctor" Schmidt. I would think that an author would do proper research before submitting a story, and that the editor would then confirm the plausibility of the futuristic science and technology appearing therein. Obviously, neither of these things was done in "Redneck. . . ."

Case in point:

1) In Throop's story, the aliens have hidden from humanity for decades by sequestering themselves on the dark side of the Moon. Thus, as Mr. Throop ineptly put it: "eluding both the senses and *radar* technology of the human race." Since this story is supposed to take place in *our* Universe, perhaps Mr. Throop forgot about the satellites that have orbited the Moon, such as *Clementine*, which took detailed pictures of the surface. Perhaps Mr. Throop forgot about the *Apollo* mission, and that while two men walked on the surface, the command module flew right over the dark side. This goes way beyond "radar" technology, yet no explanation for these events were given.

2) The aliens in Mr. Throop's story survived by: "harnessing power from their advanced solar technology." Give me a break! How can anyone gather solar power from a place where the Sun doesn't shine?!

3) Lastly, the seemingly unstoppable invasion fleet is overcome when the aliens die off upon discovering that their physiology isn't compatible with the microbes here on Earth. . . . Gee, where have we heard *that* one before? Philip K. Dick would turn over in his grave if he saw this blatant plagiarism!

For the sake of your career and the sanity of the readers, please do not publish any more of Mr. Throop's work. Thank you.

LEW CROOKS

via the Internet

The author replies. . . .

Mr. Crooked:

Truly, I stand both humbled and corrected in the light of your awesome knowledge. No sooner did your letter arrive in the illustrious office of *Analog*, when Stan Schmidt called me to break the devastating news.

"Kelvin!" he said, sobbing uncontrollably, "we've made a terrible mistake that will humiliate both of us in front of hundreds of thousands of people, effectively ending both of our careers! Whatever shall we do—we're ruined!"

Yes, even Stan's ironclad will had broken down in light of this travesty. After reading your letter to me, the two of us stayed on the phone for hours, checking all manner of scientif-

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ic references in the faint hope of proving you wrong, but alas, our vindication was denied and you were shown to be smarter than both of us in science fact *and* science fiction (except for a few colossal details that we suggest *you* look up). Stan has already made plans to rename the magazine *Lew Crooked Science Fiction and Fact.*

I hope that you will accept our apology, and if we're not both in the poorhouse tomorrow, we'll make every effort not to publish such rubbish again.

KELVIN THROOP
None of your beeswax, USA

P.S. Now that your ego and confidence has been self-righteously built up to colossal proportions, please refer to the bottom right-hand corner of the opening artwork for "Redneck." In little bitty 7pt. type, *right below the title,* it clearly says: "A spoof." Oh, how the mighty have fallen!

You're probably pretty angry right now—I know I would be if I were in your position. But think of all the laughter and joy (especially the laughter) you'll be bringing to people all across the world after they read your letter and my response in this column. What more could a person ask for?

Dear Mr. Schmidt,

The game is up! Over the past several years, I've used my exceptional powers of deductive logic to make an astounding discovery: KELVIN THROOP IS NOT REAL!

That's right, oh loyal readers of *Analog*: for years you've been a victim of an on-going conspiracy of editors to deceive and manipulate you, starting with John Campbell and continuing right up to the present day. But the Public Has A Right To Know.

First of all, Mr. Schmidt, let me congratulate you and your predecessors on a job well done. You've managed to deceive hundreds of thousands of readers from many different backgrounds of life. But I've come along and foiled your plan. Ever since the day a psychic told me that I was the reincarnation of Sherlock Holmes's smarter brother, I knew I was different.

Upon reading Mr. Throop's Biolog, which appeared in the Mid-December 1984 issue, I called Information and asked for the phone number of one Kelvin Throop, supposedly living in New York City, but they had no records of any such person! Note that they didn't tell me the number was *unlisted,* which implies that he has one, but rather that there was no account. I then called the United Nations building, where Mr. Throop is allegedly employed, and lo and behold, they didn't know who I was talking about! Well, well, well, isn't that interesting?

Don't ooh and ahh yet, folks, my genius doesn't stop there. It just so happens that at the time of that Biolog in 1984, the office building of *Analog* was located only three blocks away from the UN building . . . are you starting to see the connection?

The blatant fact is that John Campbell and Ben Bova were Kelvin Throop, and Stan Schmidt took over this false identity when he began editing the magazine. At first, they tried to pass him off as someone who tem-

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porarily took over the editor's job (a likely story!), and later on as an author. But my innate superior intellect has ferreted them out and exposed them for the world to see. Why did they do it? The answer is simple: money. By writing as Kelvin Throop, these nefarious editors are buying stories from themselves as though they were someone else! The public doesn't know, and their own company doesn't know. Very clever, but not enough to get by me.

It's all a conspiracy.

EUGENIUS MAXIMUS
One of them British Isles in the UK

The author replies. . . .

I'm a science fiction writer, you idiot, and I don't make enough money to maintain a phone account! The reason my existence was denied by the UN, is that my position there is Ultra Top Secret, and no one is supposed to know about it. As a matter of fact, so few people know that Accounts Payable doesn't pay me, because they have no records, and thus I have to make ends meet writing SF, which is to say I'm poor, and brings up the question that if the UN doesn't pay me then why on God's Green Earth am I still working there?! Nevertheless, the receptionists go by the usual policy: deny everything (including my paycheck!). Jay Kay Klein wasn't supposed to print that in the Biolog you read, but I didn't see the finished product until everyone else did—when the magazine hit the newsstands.

As to my existence, I would invite you over for a barbecue, but since your letter reminded me too much of myself, I don't think I could stand you.

KELVIN THROOP
I don't have to print where I'm from because I'm a pro, USA ■

(Biolog continued from page 47)
education service offers Creative Writing courses, some taught by SF writers, and seminars with the type of insight previously found only in science fiction linking technology with society. Expected soon is a full MA program in Science Fiction Studies under the aegis of an appropriate university.

Paul's hopes for the future center on the ability of humans to avoid the genetic hardwiring of all other species by making use of programmable brains. People needing a sharp instrument do not spend generations growing bigger teeth but design a new tool. Using one's brain is the very essence of humanity.

Paul reaffirms Hugo Gernsback's contention that technology is the key to a better world for people, coupled with John Campbell's insight that social engineering is needed as well. What was once taught almost only in the pages of pulp magazines, now goes out over satellite-links.

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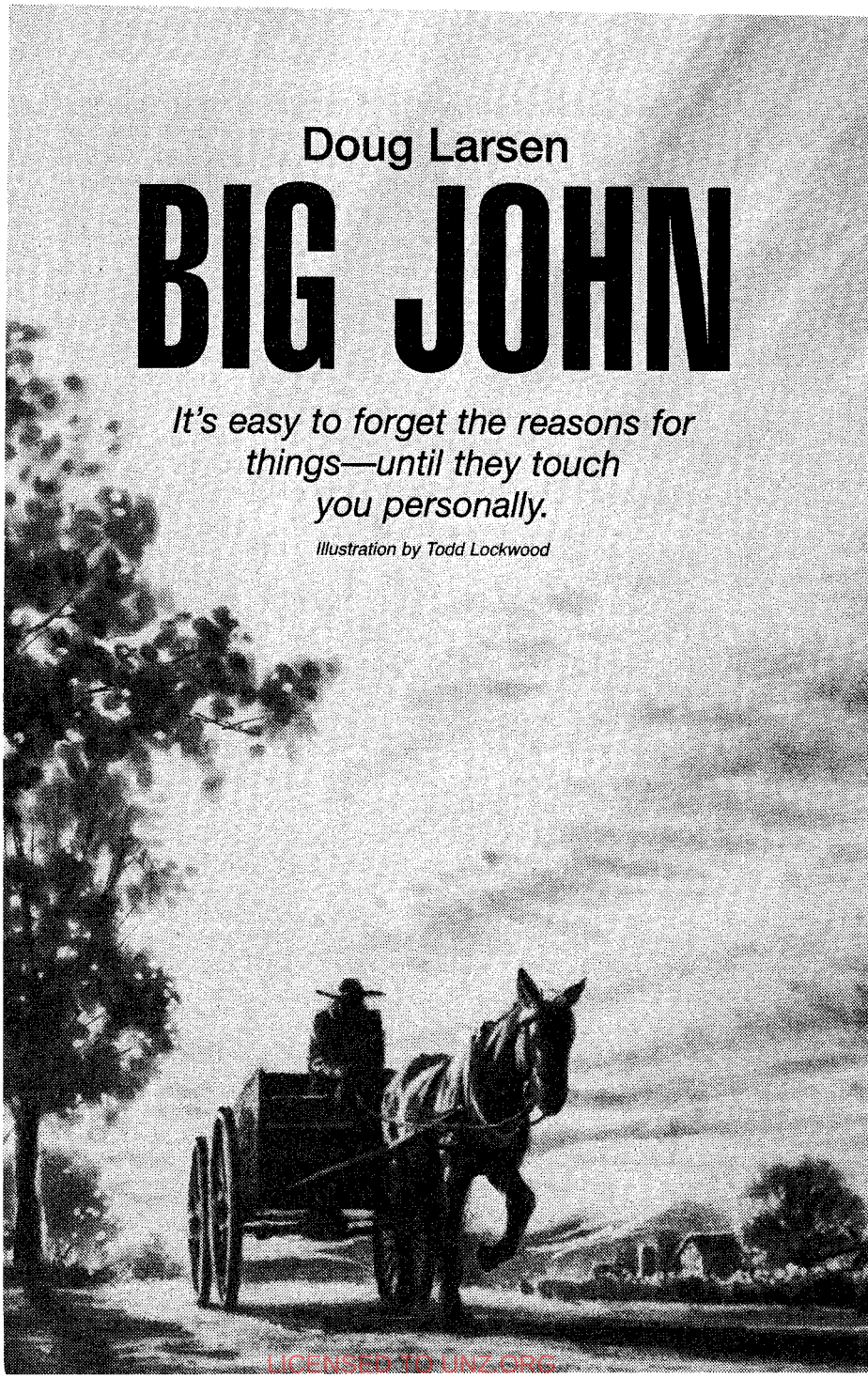
Doug Larsen

BIG JOHN

It's easy to forget the reasons for things—until they touch you personally.

Illustration by Todd Lockwood



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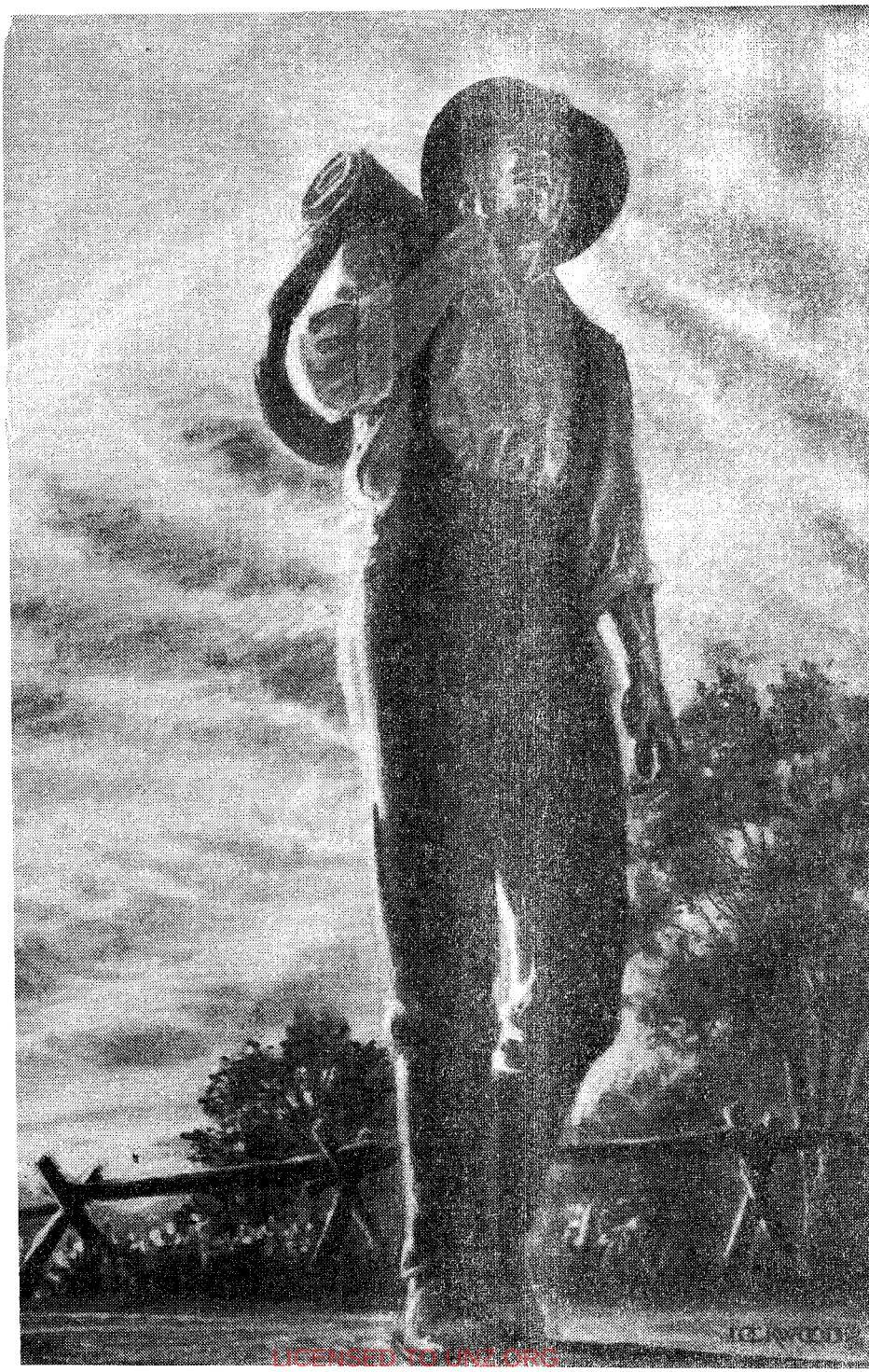

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Mr. Degeneres looked at me appraisingly, his richly appointed office looking jarringly inconsistent with the desperation on his face. "Do you think you're up to this, John?"

"I think so, sir. I really do." The sour feel of fear was sloshing around in my stomach.

"You're our last hope, you know."

I nodded. I knew.

He produced The Belt. "Here's your video gear. Remember, try to keep this part clean. It looks like a decorative stone, but it's actually the video lens. You trigger the camera by running your finger down the length of the metal buckle. It's calibrated to your fingerprint."

I nodded. "What kind of memory have you managed to get for me?"

Sara spoke up, the strain sounding in her voice. "We've managed to pack in twice as many flash memory chips as before. Basically, there's a row of them between the two leather strips that comprise your belt, and a row of them on the inside. It ought to afford you over sixty hours of recording time."

"Sixty?" I repeated. "You were aiming for eighty or more."

"I know." She shrugged. "But you're going to be down in the mines. The light sucks down there. We had to use a lot of space for image enhancement circuitry and automatic iris control. We don't want to make you look like you're diddling yourself when you're actually trying to set light adjustments."

Mr. Degeneres spoke up. "Those flash chips are somewhat flexible, but not indestructible. Be careful with the belt. And one other thing: it looks innocuous, but it won't stand up to close inspection."

I was looking it over. "What's this?" I asked, indicating a fingertip switch connected to a thick bulge in the belt.

"That's to make up for only having sixty hours of memory," Sara said. "We're not sure of its reliability, so only use it if you have to. Basically, it dumps all of the memory in your chips, and transmits all of the information through the space-time continuum to our receiver here. So in theory, we'll have all of your data, and you'll have another sixty hours of memory space."

My sour mood matched my sour stomach. " 'In theory,' you said. What about in fact?"

She shrugged again. She was doing that more and more these days. Not that I blamed her, what with the political tide moving relentlessly against us. "In fact," she said, "it's never been tested in actual time travel. But it works in the labs, and there's no reason to think it won't work in actual applications."

"But there's no proof, either," I finished for her.

"Exactly."

Mr. Degeneres spoke up. "Judicious use of your memory will make it unnecessary," he said. "Remember, we're only after an hour-long documentary, and we could make do with a half hour if necessary."

"And not all of that time has to be filled with actual footage," Sara reminded. "We're planning to use charts and graphs, and some archival inter-

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view footage, too. We've spent a lot of time trying to lay our hands on anything that will advance the cause of organized labor in the public mind."

"We've got some good stuff, too," Mr. Degeneres said. "But none of it will carry any weight if we don't get actual footage of the conditions of the mining workers in the late 1800s."

I nodded absently, looking at my reflection in a mirror as I strapped on my Belt. Average-looking guy, dark hair, dressed in late-1800s average workingman's clothes, a little above average height. Nothing special. Designed to blend in. "Remind me again why we don't just use digital imaging and produce all of this footage in a studio," I requested.

Mr. Degeneres sighed. "This is a volatile political issue," he said with weary patience. "I'm the leader of the last labor union in the country, and our last few existing chapters are proposing a vote to disband us. Business interests are also trying to get legislation introduced to outlaw unions altogether."

I nodded, irritated. Sara and I, his two primary aides, knew this all too well, and it wasn't much fun hearing about it again. We had fought side by side, suffering defeat after defeat in the legislative battle for labor representation. "But why—"

"Because if it's phony footage, the other side will massacre us. Nobody will believe that we didn't enhance something, or misrepresent something. Management will know that its best tactic would be to attack the accuracy and credibility of the video, and we'd spend all of our time trying to convince people that we were being historically accurate. That's why we need actual, honest-to-God footage. That's why I'm spending the last of my money on sending you back to the 1880s to get it. When people hear about unions, they either think of corruption or inefficient policies. If this video doesn't convince Congress—and the American people—that there was a legitimate reason and an urgent need for the foundation of labor unions, then we're finished."

"Labor unions would come back eventually," Sara demurred.

"With them being illegal?" Mr. Degeneres retorted. "Having to run the gauntlet of strikebreakers and police and army violence? No! Working men and women did it once. We're not going to do it again."

Sara and I exchanged glances. When Mr. Degeneres got into what we called his History of the Oppressed Worker mood, we were usually in for a long day. He saw us look at each other, and sat back, forcing a chuckle. "OK, kids, no lectures today. We've got other things to do."

Sara came up to me and ran a scanner down my torso. "OK, now remember, the nanotechs we gave you will protect you against black lung disease, but won't keep you from coughing when you run into dust. Try to keep to yourself when you enter the mines, or else the coughing may expose you as a greenhorn. That wouldn't be the worst thing in the world, but is inconsistent with the identity we've prepared for you." She reached up and felt my shoulders, biceps and arms, and I tried hard not to show

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how pleasant it was.

"Your physical training has paid off," she said, nodding.

"Eight months of me, the weights, and the pain," I agreed.

"You'll be fit enough to be able to stand the rigors of mine life," she said. She turned my hands over and looked at the palms. "I'm not as pleased with your hands. They should be more callused. But the skin conditioning we used on you ought to protect you from most of the blistering."

"It won't hurt to cultivate the persona of a loner," Mr. Degeneres added. "We've briefed you as well as possible, but we're still not sure how thoroughly you'll be able to pass yourself off as one of them."

I nodded, feeling more and more fear in the pit of my stomach. "Let's get this over with," I gritted suddenly.

"OK," they said in unison. Mr. Degeneres came up and shook my hand. "Good luck, John. We're all counting on you, and I know you'll do well. And just remember: it's only two weeks. At the end of that time, the time machine will find you and bring you back here, no matter where you are. Even if they decide you're some suspicious character, we'll zip you right out of a jail cell and bring you home."

I nodded. "Thank you, Mr. Degeneres. I'll do my best."

He clapped me on the back and stepped aside. Sara came up and clasped my hand. "Two weeks. I'll see you in two weeks. Right?"

"Right." I looked to my right and saw the time machine less than an arm's length away. Suddenly I was terrified, and Sara seemed very close. I took her face in my hands and gave her a hard kiss on the mouth.

She stepped backwards in surprise, and then her eyes brimmed full of tears. She grabbed my head and gave me a hard kiss in return. "You come back," she choked. "You come back in two weeks, understand?"

I nodded, not trusting my voice. I turned and climbed into the machine.

Hans Deckert was surprised to see a fellow walking alone so far from town. From here it was a good walk without a horse, and the stranger had none. Hans reined in his horse, and his wagon jounced to a stop. The fellow looked up—a tall, strapping fellow with black hair and dark eyes. The look on his face, too—one who was expecting trouble, and seemed ready to deal with it.

"Hello, *mein Herr,*" Hans called quickly, trying to project cheerfulness. "Are you needing a ride into town?"

The stranger looked at him with those dark eyes, and Hans felt a twinge of fear. But the stranger seemed to hesitate. "Is it far?"

"*Ja,* it is far, for a man on foot. More than a mile, maybe two."

"They got me pretty close," the man muttered so softly that Hans wasn't sure if he heard right. But then the stranger was climbing in beside him. "I'm grateful," he said simply.

"*Ach,* next time, I will be needing the ride, and you will give it to me," Hans said expansively. He clucked to the horse and they moved off again.

The stranger sat silently, seeming to

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be sunk in his own thoughts. Hans kept glancing at him, and finally made an attempt. "And what are you doing out here, so far from town, *mein Herr?*"

The stranger looked at him with a scowl, and Hans regretted the question. He quailed before the hard stare, and spoke quickly. "I'm sorry to ask," he said. "Your business is your own."

The stranger looked away, and then spoke. "I'm looking for a job in the mines."

"The mines, *ach,* they always have work for another man. For such a man as you, there will be no problem."

The stranger looked at him. " 'Such as me?' What do you mean?"

"I mean no offense," Hans said hastily. "I mean only that you are the biggest man I have ever seen. They will be glad to hire you."

"Really?"

"Ja!" Hans assured him, thinking he was asking for reassurance about the hiring situation. "They will hire you, or my name is not Hans Deckert."

The stranger seemed to hesitate, then offered his hand. "John. John Andropolis."

Hans shook his hand. "Well met, well met." He turned back to the road and looked at this John Andropolis out of the corner of his eye. An odd enough last name, although nothing remarkable in this area crawling with Poles and Czechs and Norsks, where an honest German felt out of place. *But no last names for you, my massive friend,* Hans thought silently. *You I will call Big John. And a man like you could come in handy. Yes.*

"So, John—Big John—have you a place to stay in town?"

Big John stirred at the use of his nickname, but then gave a small smile. "No. Nothing yet."

Hans waved it away as a minor detail. "No matter. You must have supper with me and *Frau* Deckert, and then I show you to the boarding houses in town, *ja?*"

Big John considered, then nodded slowly. "I'm grateful," he said again.

I didn't know what I expected, but I hadn't expected to be befriended so early. It was disconcerting. I was trying to be a loner, and I seemed to have convinced this little guy of that. If he thought I was so big, that wasn't saying much. What was he—a little over five feet tall?

We clopped slowly into the mining town, the potholes just about jouncing the teeth out of my head. Hans seemed to know most of the people, and waved to several. They waved back and stared at me. I gave them my dark look I'd perfected at the Collective Bargaining table, and they looked away.

Hans pulled up to one of the dilapidated shacks that huddled in with the others with a mud yard facing the rutted street. I activated my belt camera and got a good pan shot of the wretched neighborhood, and then a slow zoom at his house. He called toward the house, and a woman came out.

I stared at her, and tried to look impassive again as Hans introduced me to Helga. She was a pretty little thing with light brown hair, in her mid-twenties, with delicate features and a

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stomach that announced that she was about eight months pregnant. I looked closely at Hans again, and reduced my guess about his age by fifteen years. He was about twenty-five. He looked forty.

I was shown into their shabby hut, and was almost overwhelmed by the poverty that these miners lived in. But they didn't act like they felt poor, and their hospitality was wonderful. I complimented Helga on the meal we ate, and tried to get them to tell me about themselves, so they wouldn't have the chance to ask about me.

"We are German peoples, in America for seven years living," Helga said. "And where are you from, Herr Big John?"

I did not have the ability to cut her off rudely as I had with Hans, so I called on the story Sara and I had prepared. "Louisiana," I muttered.

"Donnerwetter!" Hans exclaimed. "Louisiana, she is far from here!"

"How come you so far from your home?" Helga asked with sweet concern.

"Trouble," I said evasively. "I don't like to talk of it."

"Of course," she said tactfully. "We will have no more of it."

Hans pushed his empty plate away. "So. We are finished. Come with me and I will introduce you to some of the fellows," he said, smiling broadly.

Helga smiled quietly. "He means he would go and drink beer," she said. "But not too much, please, Hans. And not with the trouble man." She didn't seem to be referring to me.

"Of course not, *Liebchen.* Come, Big John. You must meet the men you will work with tomorrow. They are mostly a good sort, although many Poles and Norsks and Czechs. But there are some Germans still. And no Irish, thanks to God."

Helga nodded, her face screwed in disgust. "The Irish are animals," she told me.

"Even worse than the Swedes," Hans agreed. "Some tried to live here among us. They quickly learned otherwise. Come. We will get a drink."

I walked with him, ignoring his chattering. I was stunned by the comments of this friendly couple. So they hated the Irish and the Swedes. They hadn't even mentioned blacks. But then, even though the AFL formed around 1886 and worked to improve working conditions in mines, blacks weren't allowed in the union for decades after. I supposed that if Hans ever joined a union, he'd feel he was being excessively tolerant if he allowed Swedes to be in the same union.

How the country had changed! I wondered how he would have felt if he knew that I came from a time where all of the ethnic groups that he so carefully differentiated were grouped together simply as "Caucasian," and were no longer a majority. And how would he have felt if he knew that my president was black?

Hans pulled me out of my reverie by gripping my arm. I looked at his hand, surprised, and he mistook it for displeasure. "I'm sorry, Big John. I merely wanted to point out the tavern."

It was a small, sprawling, ramshackle place that seemed full of men.

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Loud laughter and tortured strains of music were coming from it. I activated my belt video and got a good view of the tavern and some of the men staggering out and falling into mud puddles.

We walked into the building—*gad, that's right, they still smoked back then!*—and Hans shouldered his way up to the bar. Mr. Degeneres had supplied me with authentic money he had obtained from a collector, but Hans waved me off. "*Nein,* it is my treat tonight. Come. We will drink."

I knew he must not have much money, but he was determined to be hospitable. We found a table and sat down. We drank, and he beamed at me.

"Is goot, *ja?* It cuts the dust in a fellow's throat."

Before I could reply, a voice boomed from across the room. "So, ve haff a *Chermann* in our midst!"

Hans and I looked to the source of the noise, and Hans seemed to tense up all over. A man was weaving over toward us, pointing at Hans. "I tol' you never to come here again, Herr Chermann!"

Hans glanced at me, and then looked coldly at him. "Go away, you stupid Polack."

The man lurched at Hans, more than a little drunk, and outraged by Hans's words. "You filthy Chermann! I'll kill you!"

This was clearly not the time for a "let's not fight each other; let's band together and fight management" speech. I got to my feet and stepped between the drunk and Hans. "Leave him alone," I said. I noticed that the room had become quiet, except for an undercurrent buzzing of "who is that man?"

The drunk looked at my chin, and then slowly looked up to my eyes. He seemed impressed, but too drunk to think about it. "Who are you, and why do you protect Chermann filth?"

Before I could answer, Hans popped his head around me. "He is called Big John," he offered, and then retreated quickly.

"I don' like your smell!" the drunk yelled.

"Go sit down." My adrenaline was pumping, and I kept reminding myself that these miners were strong. But probably very few of them had taken martial arts self-defense courses that every union organizer felt was necessary in my time. Anti-union violence hadn't stopped in the 1930s. Besides, I lived in New York. Self-defense training was almost required by law.

It was almost too easy. The man was so drunk he telegraphed his moves horribly. I blocked his punch, jabbed him in the solar plexus with three stiff fingers, and caught him on the side of the face with a right hook. He went down with a crash, smashing against a table on the way down, and lay still.

There was still silence in the room as everybody stared at me in awe. From the whispering, I gathered that I had just knocked out the town bully. Behind me, I heard Hans talking in German to some friends. He probably assumed I couldn't understand—English was probably the only common language among these groups. But Germany was a major industrial pow-

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er in my time, and I had a pretty good command of German as well as several other languages.

"I met him today, and he is friendly but very, very stern. Be sure you don't give him cause for offense. You saw what he did to that Polack! Well, there was trouble with a woman, I think, in Louisiana. I think he killed a man over her. But he does not like to talk of it."

There was a buzz of voices I couldn't quite make out. I was circling the room with my eyes, ready for an attack by the drunk's friends. But nobody was moving. Hans's voice came again: "Yes, that's his name. Big John. The strongest man I've ever seen."

A legend is born, I thought, not allowing the smile to come to my lips. That guy sure has an active imagination. I kept looking around the room. I couldn't see anyone who was as tall as me. It was amazing, considering that I was only six foot six—not much taller than average in my own time. It must have been nutrition and medical conditions. I remembered visiting Stratford-upon-Avon when I was in London at an International Order of Workers meeting, and touring the house believed to be Shakespeare's. The tops of the doorways hardly came up to my shoulders.

I gave one more look around the room, activating my camera and looking as tough as I could. If people were afraid of me, they'd steer clear. That would help a lot in my mission.

Hans drank more beer than Helga would have approved of, but he was feeling very good. He had befriended Big John, and his hunch of Big John's usefulness had already borne fruit. That obnoxious Polack who terrorized just about anyone in town had chosen him, Hans Deckert, to be his primary victim. But with one crashing right hand, Big John had leveled the tormentor, and Hans could enjoy the camaraderie of the tavern again in peace.

He staggered a little in the night air, mucking through the deep mud that was everywhere. "You are already famous in this town," he informed Big John. "Come. I will show you the boarding houses, and the employment office at the mine."

He gave Big John a drunken tour of the town, which didn't take long. "There is not much here except the mines," he confided, hiccuping. "But for a man such as you, there are many women about, if you know what I mean." He started to elbow Big John in the ribs, but thought better of it at the last moment. It wouldn't do to be overly familiar with such a dangerous man. "But here you can get settled, and you will probably start work tomorrow."

"I'm grateful," Big John said gruffly. "For the guidance and for the dinner."

"It is my pleasure," Hans said expansively. "And I am grateful in turn for your help in the tavern. That dirty fellow, he has been a trouble for many months, but I do not think he will be anymore. Good night, Big John."

Hans headed back home, weaving slightly. Everything felt right with the world on a night such as this.

As the days went by, Hans saw Big John become more familiar with the

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workings of the mine. Any experienced worker could see that the big man's stories of previous mine experience were false, for the man had some mannerisms of a tenderfoot—but a tenderfoot who somehow knew what to expect. It was puzzling. But nobody was going to make so bold as to ask Big John about it.

He was a hard worker, too, and had none of the wind fatigue that plagued so many of them. *Ach,* but that was something that would come with time. Hans had seen it happen to many of his fellows, and to himself, too.

As far as he could tell, Big John had made no friends. He talked to many of the fellows, though—and this was certainly strange!—he didn't much seem to care who they were. He talked to Polacks, those men with missing teeth and crazy eyes; with the Czechs with the impenetrable language, even the Norsks and Hungarians. He spent time with Hans and the Germans as well, of course, although Hans could have sworn that when he spoke German to the other fellows about Big John, the look in the big man's eyes made Hans wonder if the German was truly going over his head. Certainly the little English that came out of Big John's mouth was excellent, with a strange accent that Helga had pointed out was not what they imagined a Southern accent would be.

All in all, Big John was a mystery. Discreet inquiries at the boarding house he had taken told Hans that the man was a good tenant, quiet and clean—although he had made one strange request: he asked about having a bath *every* day! *Frau* Muller, the housekeeper, told Hans, "I gave him such a look, I wondered if he was a madman, and might kill me next! But he merely gave me a dark look and muttered apologies. Then he went back to his room. I was quite relieved! They say he's killed a man. It was over a woman, you know, so perhaps he won't kill again. Still, you never know."

Hans agreed that one could never know. Consumed with curiosity, he went from there to the many brothels in town, and inquired within. No, none had done business with the tall, dark and silent man who was new in town.

"Why do you wonder so about this man?" Helga asked him one night, nestled in the crook of his arm.

"I don't know," Hans admitted. "I owe him a debt of gratitude. He is fearsome, yet seems to be a good man. And his stories of his past do not seem to match up to his behavior." He did not admit the true reason for his curiosity: that it was more pleasant to wonder about this man than it was to contemplate his own future.

For it was rumored that the mine was failing. The richness of the ore was deteriorating, and profit was decreasing. And everyone knew that that would mean a decrease in the wages. Unless the mine was closed, and then there would be no jobs, and how would Hans Deckert provide for his wife and new baby?

There was talk of a new mine being started ten miles to the south, but what could one believe of such ru-

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mors? And with his increasing wind fatigue, how long could he work, even if the mine stayed open? No—it was more pleasant to be wondering about the new man, and the mysteries that surrounded him.

For there were surely mysteries. Big John often seemed to be muttering to himself, but not as one who is approaching madness. And he would stand and stare at the others as they worked or talked, standing apart from them and making no effort to join in. Once Hans found him standing and looking at a pile of the mining gear that had just been assigned to the new man. The gear was curiously arranged, as if for a portrait, and Big John stood some four or five feet from it, standing very still and gazing at it.

The man's sense of humor was rare in its appearance, and strange when used. Hans saw him pick up his miner's helmet—certainly the most mundane piece of equipment one could imagine!—and finger the candle and reflector mounted in the brow, and laugh. Not as if it were funny, but as if it were not to be believed. But why would that not be believed? Would he rather they all worked in the dark?

Another time, as they all climbed down from the train cars that took them into the mine, Hans saw Big John stop and stand to one side, clutching his belt, and staring at the canary cage being hung from a wooden stake near the work area. Then he shook his head and walked away. Hans wondered if the canary was a new innovation to the mind of this man from the south. If they had mines there, and if Big John had indeed been a miner despite any indications to the contrary, perhaps they had never thought of using canaries to warn of poison gas.

But the canary allowed Big John to show his courage. One afternoon, while deep in the concentration of work, Joachim Gonnermann suddenly filled the cavern with a shout.

"The bird! Oh, Hans, see the bird!" He was so filled with fear that he called out in German.

Hans jerked his head toward the bird, and saw it fluttering weakly in the bottom of its cage. Adrenaline inspired by pure fear shot through him. "GAS!" he shrieked in a voice that cut through the clank of picks and shovels. Other workers whirled around, electrified, and shot looks straight at the canary.

"GAS! GAS!" they took up the cry, and it spread through the entire shaft. Men threw down their tools and rushed to the train cars, some of them ignoring the cars and simply sprinting for the surface.

Quickly, the train cars were filled and the driver leaped into position. Suddenly a terrible cry came from the depths of the mine: "WAIT!!"

They turned to see Big John emerge from the shadowy depths of one of the caves, dragging the inert forms of two men with him. He carried them up to the train cars, which were already overfilled with men. He set one of the unconscious men down, and almost threw the other into a full car. "Take him!" he bellowed, and the men were too struck with fear to protest. Leaving them to accommodate the man as best they

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could, Big John picked up the other unconscious man, carried him to the next car, and threw him into the midst of men there. "Take him!" he roared again. The men scrabbled to keep the man from falling.

Big John struck the side of the car with the big flat of his hand with a thud that shuddered through the train. "GO!" he bellowed at the driver, and the driver needed no urging.

The train cars left at top speed, and Hans sat wedged in the third car and looked back at the receding figure of Big John as the train left him behind.

The train made it to the surface in time to see the throngs from the town being summoned by the alarm bell. Wives and families ran to see if their men were alive or dead, and the miners embraced their loved ones and sucked in the sweet air of the surface, never once caring about the smoke that was always present in the air.

The two unconscious miners were slowly awaking, and dozens of men were telling the story of how they were saved by Big John, and how Big John had been left behind when the trains were full. Helga was hugging Hans, who was inconsolable.

Fifteen minutes after the train reached the surface, a shout came from someone near the mouth of the mine. "Someone's coming up!"

Grabbing torches from the sides of the mine, several men ran in. The blazing torches illuminated the towering figure of Big John, almost completely spent, staggering up the mine corridor with another unconscious man slung over his shoulder.

Cries of awe and congratulation echoed off the walls as eager hands seized the unconscious man and relieved Big John of his burden. But such was his pride that he scorned other help, and when men tried to assist, he struck their helping hands from his belt and strode out unaided.

Weeping with gratitude, the wives of the three miners threw themselves upon him, hugging him and insisting that he sit and rest. He permitted the ministrations of the women where he refused the help of men, and soon was lowering himself heavily to the ground, allowing blankets to be spread beneath him.

Within an hour, everyone in the county knew of his heroism.

I slept most of the next day, and the townspeople left me alone. Only Helga bothered me, once knocking on my door and giving me a basket of food provided by the grateful families. "John Lewis is very ill," she told me in her heavily accented English, "but he is expected to recover."

"Who?"

"The third miner, the one you carried up with you. All are most grateful to you, *Herr* Big John."

I was feeling violently ill myself, so I smiled briefly at her, nodded shortly, and closed the door. I went and collapsed onto my sorry excuse for a bed, and closed my eyes. I had no idea how many nanotechs had been destroyed in protecting me against hydrogen sulfide, but I was willing to bet that it was a large chunk of them. I was running a fever as they scrambled to recover their losses. They must have been confronted with a heavy

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concentration of the stuff to lose so many of their number. But they had worked long enough, and had bought me time—how much, I didn't know, but enough to get me back to the surface. And they had enabled me to save the lives of three men, and had added considerably to my legend.

I laughed humorlessly at the thought that came into my mind. I had changed the past! Oh, no! The world would be violently different when I got back to my time.

I dismissed the thought without any effort. I had serious issues to deal with, and worrying about an old science fiction cliché wasn't one of them. In this era of the Robber Barons, hundreds of thousands of people lived and died completely unnoticed, chewed up in the industrial machines controlled by a handful of incredibly powerful millionaires: Rockefeller, Morgan, Gould, Vanderbilt, Carnegie and others. For every ton of ore mined, for every acre of trees converted to lumber, for every mile of railroad track laid, dozens of men died. And if anyone complained, if anyone suggested that workers should have working conditions that wouldn't kill them; if anyone suggested that twelve hours a day, six days a week were a little excessive; if anyone suggested that children shouldn't be subjected to those conditions, they were branded communists and beaten, jailed, perhaps killed. In the next few decades, state militias would gun down hundreds of striking workers, all in the name of fighting communism and anarchy.

A handful of men were all that mattered in the late 1800s. It didn't even make any difference who was president. A few mine workers would make no difference to history whatsoever.

I lay with my arm over my eyes, and thought about Sara. The memory of the kiss I gave her was still sizzling in my brain. We'd worked together for years, but it wasn't until I went on this potentially dangerous mission that I had the nerve to do what I'd always wanted. And, apparently, she had wanted it too. The thought made me feel much better.

I thought about some of the footage I had shot. A gas panic, a mass evacuation, three limp bodies dramatically showing how deadly the stuff was, a lurching journey out of the mine, and the tumultuous reception of the town at the end. These men lived and died with the mine, and so did their families and the town.

Amazing. In my time, only robots did mining. No human would ever endanger himself down there, even though the last human miners had enjoyed safety conditions a million times better than what these people accepted without question.

It was a million times better, because of safety reforms the unions had forced on management. And nobody in my time realized that—they took it all for granted. Not even the management of the worst companies even considered proposing working conditions remotely like what I saw here.

It must have been the poison gas that was still affecting me, because the next thought came totally unbidden.

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That's why the country doesn't need unions any more. Their work is done.

I sat up in surprise. What was I thinking? This was blasphemy!

I sat on my bed and thought about it. Nowhere in America were working conditions even remotely like this. Wage scales were standardized, and nobody had much complaint with them any more. Federal safety regulations were stringent, and were accepted by management and labor alike. National health insurance had removed one of the biggest negotiating obstacles. And the judicial system with its sophisticated arbitration procedures now handled disputes as well as any grievance committee could.

And what's more, all of this was taken for granted—by both workers and management.

When was the last time I had a fight with a company's management? Lately, all I've done is fight to keep the workers from dumping the union!

Sleep did not come easily that night.

I was back to work the next day. The "communistic" concept of paid sick days would not be accepted for decades yet, but my motivation was different. I only had a limited amount of time here. I had to make as much use of it as possible.

We were taken to a different part of the mine that day. The mining train took us only part way down, and then we walked a steep series of switchbacks, each delving deeper and deeper into the earth. The tunnels were narrow and sadly lacking in headroom, and the construction of the bracing was lousy. I recorded it all for posterity, not sure what posterity would do with it.

We finally got to the digging area. We had to explore for ore, and bring it out by hand, before the company would decide whether the new area was worth developing enough to accommodate a train and heavy traffic.

I looked blearily around the flickering hellhole. Yeah, whoever had worked to improve mining conditions from this crap had done an enormous amount for the working man. There was a reason men risked death by fighting for their unions in the late 1800s—they had so much to gain. And the unions had improved their lives immeasurably.

What have I done?

I'd spent my entire adult life working for unions. But had I done anything to make life better for working men and women?

No.

I finally understood why Sara and I had suffered defeat after defeat. I finally understood why Mr. Degeneres had lost his influence. The perception was that we just plain weren't needed any more.

And I wasn't sure they weren't right.

The men were really steering clear of me today. The look in my eyes must have matched the feeling in my soul—the despair of realizing that I've wasted my life. And realizing that the ideals I've lived by my entire life were wrong.

The only good I'd ever done any-

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body was here in the 1880s. If I looked back on all of my accomplishments in my own time, I'd have to admit—*what was that!*

I jerked myself back to my present situation, and noticed that all of the miners had frozen, the whites of their eyes reflecting in the flickering light as they all looked upward. Like me, they were listening intently, in an agony of fear, and then it came again.

. . . A low, soft groan. . . .

It wasn't a human sound, but the ominous, subtle warning of wood that was giving way. Suddenly, as never before, I was aware of the thousands and thousands of tons of rock and soil above us. Without thinking about it, I activated my camera.

. . . And again. . . .

It was Hans Deckert who broke the thrall as his spade clattered to the ground, and his voice broke the spell.

"Out!" he shrieked. "It's a cave-in! Everybody out!"

Suddenly we were all moving, everybody shouting, a panicked stampede toward the only exit, everybody yelling in fear, so if there was another groan, none of us heard it.

. . . But we felt the rumble.

We were all scrambling, pushing, shoving, yelling, bolting for the exit, and the rumble knocked some people off balance. And then a board gave way with a snap, and rock and soil crashed down just a dozen feet ahead of the miners in front, smashing down in a ripping, tearing, rumbling cascade of dirt and dust and our only escape route was pulverized and obliterated by tons of earth, and we were all knocked off our feet by the power of the fall, screaming and yelling and coughing as dust filled the air and we fought to breathe. I lay flat on the ground, with two men thrown on top of me, and my ear was pressed to the dirt, and I didn't hear or feel anything but the noise of the men in our dimly lit grave.

We scrambled to our feet and groped around. Most mens' candles had gone out, and only two torches remained in the narrow, crowded cave.

"Trapped!" Hans yelled. "Oh my God, we're trapped!"

A miner's worst fear; something that didn't even exist in my time. With the construction techniques we used in the mines, there were never any cave-ins. And even if there were, the robots were designed to withstand enormous pressures, and would just shut themselves off until they were dug out.

I knew all about mines in my time. The technicians who maintained the mining robots had voted to disband their union five years before, figuring that their union dues weren't getting them anything they wouldn't get anyway.

I looked around and realized that cave-ins had happened all over the place. Through some miracle, the only part that hadn't collapsed was a short section of tunnel that we were all in. As it was, we were piled on top of each other, and were probably looking at a slower, more dreadful death than if we'd been crushed.

There was pandemonium in our cramped space as every miner cried and yelled in panic and despair. I tried

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to shut out the noise and think, but no ideas came. We were trapped here. The limited air supply didn't even allow us to try to dig ourselves out. All we could do was wait and hope that rescue came before the air or the rest of the support beams gave out.

There was another groaning noise that I heard over the pandemonium because it was so close. I looked up in alarm, and saw one of the support timbers actually bending! It started giving way, letting loose a series of rifle shot cracks that got everyone's attention. The yelling and panic increased, and I knew if that beam let go, the whole roof was going to come down on us. I leaped to my feet and put my shoulder to the sagging beam. I spread my feet wide apart, kicking men in the process, and then I focused every ounce of strength in my body and heaved with all my might.

The beam stopped sagging.

There were cheers from the miners now, and Hans was encouraging me at the top of his lungs. "*Ja,* Big John, you can save us all! Hold it! Hold it up!"

I moved my feet in closer, gasping for breath, and gathered myself together. I gave another enormous heave, praying that nothing would pop in my back. But it wasn't my back that gave way—it was the ceiling to one side of the beam. Dirt cascaded down, and the only reason it didn't kill me was because my head was on the other side of the beam. Men yelled and scrambled away from the pile of dirt, but when it stopped, Hans scrambled up it and peered upwards.

"Light!" he yelled. "I see light up there!!"

I risked losing control of the beam, and turned so my head was on the other side, almost breaking my neck in the process. It was true. Twenty or thirty feet above, I could make out a dim pool of light. It must have been from torches in the zigzag tunnel above us. Some of its floor had given way, and left a narrow, irregular tunnel up to it.

And then I knew what I could do to help the working men of the world.

I met Hans's eye, and gestured upward with my head. "Go!" I barked. "Stand on my shoulder! Climb up!" I gestured at the others. "All of you! *Go!*"

Hans looked wild. "But how will you—"

"Come back for me!" I roared. *"Go!"*

He nodded quickly, and scrambled up the dirt pile that was spilling around my legs. He put one of his miner's boots on my shoulder, and pushed up. Dirt showered around me, matting my hair and clogging my throat as he scrambled upward. The others were right behind him, clamoring for their turn. I wasn't sure if they'd be able to claw their way up to the other tunnel, but one by one they disappeared.

Leaving me alone.

The beam pressed down hard on my shoulder. I looked up at the tunnel, now partially obscured by the frantic scrabblings of twenty men. I heard their shouts fade away as they dashed for the surface, and I was left in silence. I knew that if I let the beam go and made a break for it, I wouldn't get six inches. Everything would collapse on me, crushing me instantly.

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Next to my ear, the beam creaked evilly, and I pushed harder against it. There was a slight trickling sound from the dirt that was coming into the chamber. And there was the rasping sound of my breath as I tried to keep the beam up.

Nothing else.

I remembered my video belt. It was still recording, both video and audio.

"I'm John Andropolis," I gasped, my voice filling the empty chamber. "I'm alone here at the bottom of the mine. I've just saved twenty miners from a cave-in. They're coming back to save me, but I don't know if they'll get back in time.

"You may look at this video and remark how much better things are than they were in 1880. You may even conclude that things are so much better, we don't need unions any more." I shifted my feet to keep a firm footing in the drifting dirt. "Well, maybe you're right. For the first time, I understand why I've had no success battling against the anti-union movement. It's because people don't think they need unions any more." The dirt was flowing faster, and I was struggling to keep my feet. "So I guess if union membership goes down to zero, that wouldn't be so bad. But voting to outlaw unions would be a disaster. Because I firmly believe that it's the threat of unionization that makes some companies keep working conditions so good. And if that threat goes away, some of you may someday find yourselves in a place like this." I fumbled for the fingertip switch inside my belt that would transfer all of my data back to my time. "That's all I have to say. Sara, I love you."

Hans Deckert was at the head of the pack that was charging back down the mine tunnel, staggering under the weight of a bunch of lumber. *We will get down there with him, and we will support the beam with this wood,* he thought desperately. *And then we will be pulled up by rope held by the rest of these fellows.* "Hang on, Big John!" he yelled at the top of his lungs. "We are coming to get you!"

They were halfway to him when the rumble knocked them off their feet.

They held the memorial service the next day in the Lutheran church. Hans Deckert, who knew him as well as anyone, tried to say a few words, but was too overcome with grief to manage much. He broke down completely, and stood with tears streaming down his face until Helga came and led him off the podium.

"He was a good man," Hans said brokenly. "No matter what he did elsewhere, he was a good man for us. Although he was here for only two weeks or so, he helped us."

Helga nodded, her eyes filled with tears as well. "If only we knew where to go," she said sadly. "We could find that girl he loved, and tell her how bravely he died. She would be proud."

A company official walked up to the podium and announced that the damage to the mine was extensive. "We will not reopen it," he said. "The ore is of poor quality now, and there is no profit in continuing it. However, we are opening a new mine about ten

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miles south. There will be jobs for all of you there."

After the ceremony, a group of men gathered outside. "If the mine is not to reopen, it is a fitting grave for Big John," one said.

"In that case, we should make a marker for him," another said.

A third man chimed in. "It must be large. Marble. With a suitable inscription that tells of his name and his prowess."

Hans nodded vigorously. "*Ja, ja!* And we must tell his story often. He was a hero, you know. A legend in his own time!" ■

IN TIMES TO COME

Our May cover, by George Krauter, introduces Bud Sparhawk's novella "Primrose and Thorn." What, you may ask, is a sailboat racing story doing in *Analog?* Well, sailing in the atmosphere of Jupiter is more than a little different from sailing on the oceans of Earth—and, in important ways, a *lot* more interesting. Especially since in this case the race is being conducted in a very large and very alien wilderness, and the racers aren't the only people using it. Which means their sport can easily turn into much more than they anticipated. . . .

G. Harry Stine's fact article looks at one of the less technological problems of space travel: "Will They Let the Spaceships Fly?" Being able to fly them is one thing; getting permissions from all the necessary government agencies is quite another!

And, of course, we'll have the usual diversity of additional fiction, including the Conclusion of Charles Sheffield and Jerry Pournelle's *Higher Education* and stories by G. David Nordley and James C. Glass.

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THE ALTERNATE VIEW G. Harry Stine

SELDON'S PSYCOHISTORY

A growing number of historians—some people consider me a historian and I claim to be an aerospace historian—are starting to express an interesting series of new thoughts. These appear to be based on the view that history is a branch of the biological sciences. Therefore, its ultimate expression may be mathematical.

Where have science fiction readers heard this before?

Pick up Dr. Isaac Asimov's *Foundation* novels. I have all three of them collected between one cover; saves shelf space, which is *always* at a premium.

There you will learn about "psychohistory," a fictional branch of science invented by Asimov's mathematician character, Hari Seldon, on the planet Trantor in about the 12,050th year of the Galactic Era. At the start of Chapter 4 of Asimov's novel, *Foundation*, is the following excerpted definition of psychohistory:

"That branch of mathematics which deals with the reactions of human conglomerates to fixed social and economic stimuli. . . . Implicit in these definitions is the assumption that the human conglomerate being dealt with is sufficiently large for valid statistical treatment. . . . A further necessary assumption is that the human conglomerate be itself unaware of psychohistory analysis in order that its reactions be truly random. . . ."

This novel appeared in this magazine during World War II.

It was fiction then. It may become fact like many other SF forecasts of the period. As usual, herein lies one or more problems. . . .

Present-day historians are a strange lot. They tend to be academically oriented and to dismiss as non-historians those who actually participated in making history and have written it down, either as a personal memoir or as a dispassionate narrative of what took place because they were there when it happened. Thus, many books by people such as Willy Ley and others who were involved, actively or as bystanders, in the development of space flight are not considered to be "valid historical documents." Yet J.C. Caesar's *Gallic Wars* is considered to be a history book. Go figure while I climb off my soapbox here. . . .

Historians are starting to realize that they have been groping their way

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through narrative history. This is told as a series of national heroes, national actions, and crises internal and external to nation states. It is an often colorful recounting of wars and other conflicts, mostly involving death and destruction.

Very little attention has been paid to economics, trade, and business.

In fact, nowhere in the 11 books of *The Story of Civilization* by Will and Ariel Durant will you find any discussion whatsoever of the corporation. This was a business organization evolved by the Dutch and the British in the era of exploration and colonial expansion as a way to protect the individual participants against the corporation's creditors.

In fact, the history books usually treat economics and trade incompletely if not badly. These human activities are viewed as secondary activities when, in fact, they provided the motivation for the existence of many empires and for most of the great engineering and technological feats of antiquity. The reason? Probably because economics and trade are nowhere near as arresting and fascinating as conquest and death. Mystery and detective novels still outsell romance novels while history books don't even run a distant third. Criminal murder trials preempt other television fare.

History teachers try to make their subject interesting to students, but they have to work pretty hard at it because of the competition from the newspapers and television. They have enough trouble trying to overcome the student MEGO (My Eyes Glaze Over) phenomenon because their narrative history approach just tells stories of kings and princesses and knights and wars and death and destruction. This is the same sort of material that any student can find in much more exciting form on the "science-fantasy" shelves at the local book mongers.

It isn't going to get any better for history students because history is now becoming more interested in sociological and economic factors. Historians are beginning to take notice of steel production rates, agricultural prices, demographics, gross domestic product, monetary exchange rates, and other factors whose magnitude and trends have been tracked and analyzed with our improved technologies of communication and data processing.

The magnitude of this change of focus by historians can be sensed by trying to apply the new terminology and approach to the classical world in a comprehensible way. When modern economic questions are asked about the Roman Empire, the answers come back as a "don't know" or an educated guess.

From time to time in past columns here, I've tried to get some handle on historical trends by using some of the new history approaches. Trying to determine the modern value of the florin, for example, leads to a wide spread of value guesses. We ask the simple question, "How could they *afford* to fight that war?" The answer is usually "don't know" or "doesn't make any difference." Today, we ask: "Can we win, what will it cost, and is it worth it?"

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What were the economic motivators that drove the Phoenicians and Carthaginians? We don't know.

What about the Hanseatic League? We don't know.

What caused the collapse of the great Chinese trading empire under the Ming dynasty? We don't know.

Why did the Fuggers and the Medici gain control of the trade of Renaissance Italy? And what caused the fall of the trading city of Venice? Why did the Swiss win in the long haul when it came to international banking, and why did the Brits lose? Did the United States really go into southeast Asia to save the gold debasement center of Saigon?

Historians try to answer these questions, but mostly using the old techniques of narrative history. They're probably frustrated about not getting answers because (a) they have little if any education, training, or experience in economics and business, or (b) the data aren't there.

The study of ancient history is probably going to remain unchanged while history itself passes into this new stage that begins to show a very strong resemblance to Asimov/Seldon psychohistory.

However, the historians have a difficult road ahead of them.

If history is considered to be a branch of the biological sciences whose ultimate expression must be mathematical, the historians need to be aware that the biological sciences are only just beginning to gain the sort of rigor that math has given to the physical sciences.

And the historians need to be careful about their increasing interest in and use of sociology. That field of science is still what might be termed "emerging." It's full of platitudes expressed in jargon. It lacks the ability to test its hypotheses without using very large human systems over a long period of time, and said system is exposed to dire consequences if the experiment should fail.

We have a golden opportunity now to study the failure of a social/economic system. However, since the collapse of the Soviet Union in 1991, I haven't seen any activity in that regard. Maybe I'm not reading the right journals. (If that is the case, I know you will tell me.) And the sociologists and historians are faced with a massive campaign of excuses: "It *should* have worked! We didn't *try* hard enough! We didn't have enough money to make it work right! And we couldn't get everybody to cooperate!" We see that sort of thing right here in the USA with the breakdown of government social programs, and it can also be seen in other countries where it has progressed further.

The encouraging fact is that we have a growing data base that is accessible to nearly anyone who is interested. Two points do not necessarily determine a curve or a trend. Chaos theory can be helpful in sorting out the statistical nonsense and revealing the ultimate consequences of the initial assumptions—something that is true of the application of mathematics in any of the sciences.

There is another major consequence of the wide and general availability of data. It prevents the creation

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of a priest/brahmin class. This presupposes that many people use the data base access available to them and have the education, training, and intelligence to use that data.

Hari Seldon's psychohistory may become a real science much earlier than Asimov had forecast. However, I may have rendered psychohistory invalid or inconsequential because I devoted this column to it. Asimov understood science very well, and he incorporated the Heisenberg Principle into his definition of psychohistory. The observer *always* affects the result of the experiment, no matter how carefully the experiment is designed. Psychohistory is no different from economics or nuclear physics in this regard.

A major problem exists in doing this because there is a *delay* between the time something happens and the time someone figures out what caused it and can recommend corrective action. This can cause the system to go unstable. However, once the system is truly understood—and it probably won't be because history shows that the system changes even while it's being studied—then negative feedback can help keep it stable.

But do we want a stable system? Does this mean that technical, economic, and social progress is stalled? Does this mean that we regress into a world where every day is just like the day before . . . and the day before that?

I'd like to see the continuation of the dynamic system we now have. But I don't know how to use all the information and data to improve it. I don't have the answer(s). All I can do is call attention to the problem(s). I don't believe there are any quick or easy answers. There never have been. But unless people start to think about problems, answers are never found.

Write to me at gharry@bix.com. I always value feedback, and I get a lot of it. ■

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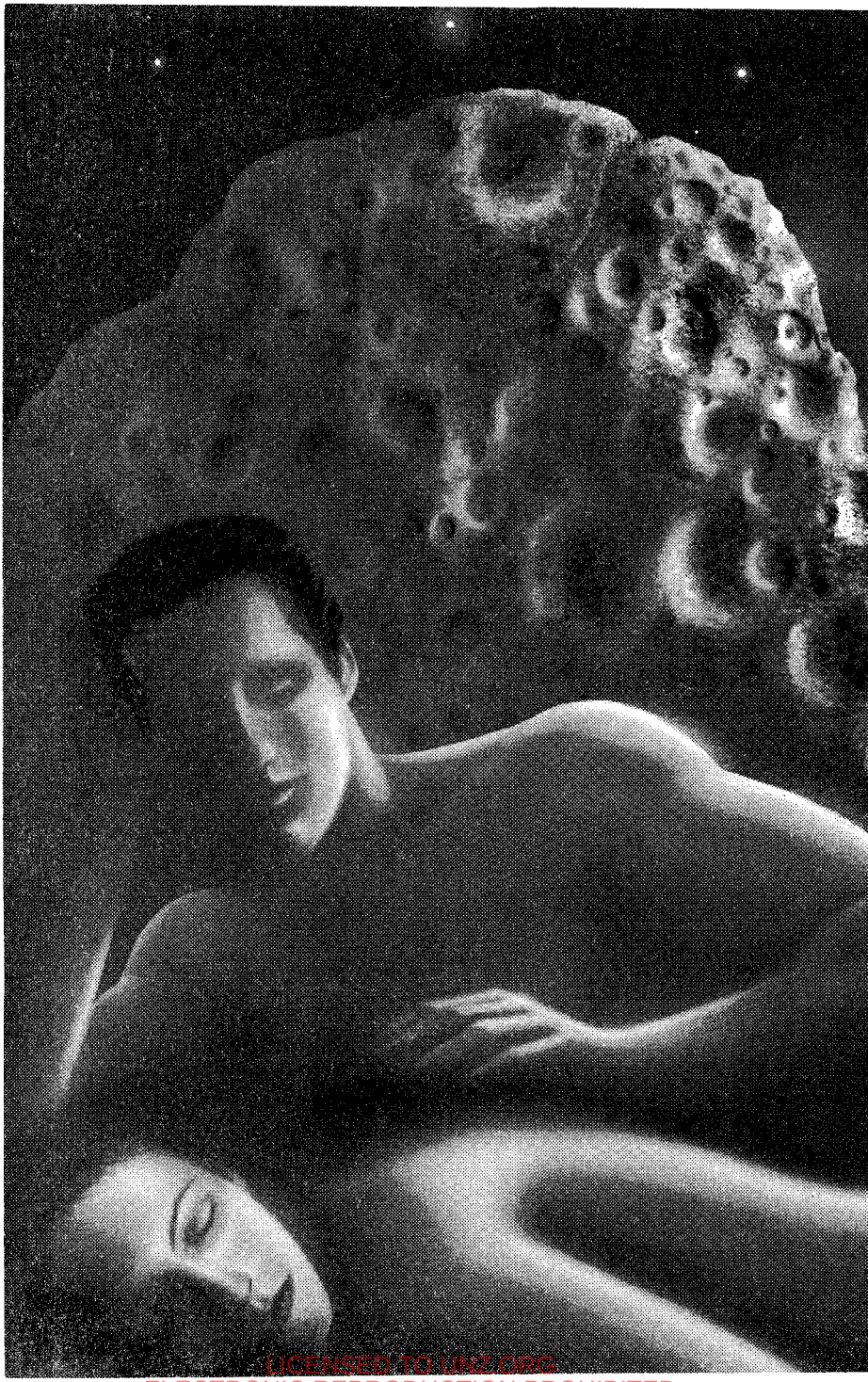

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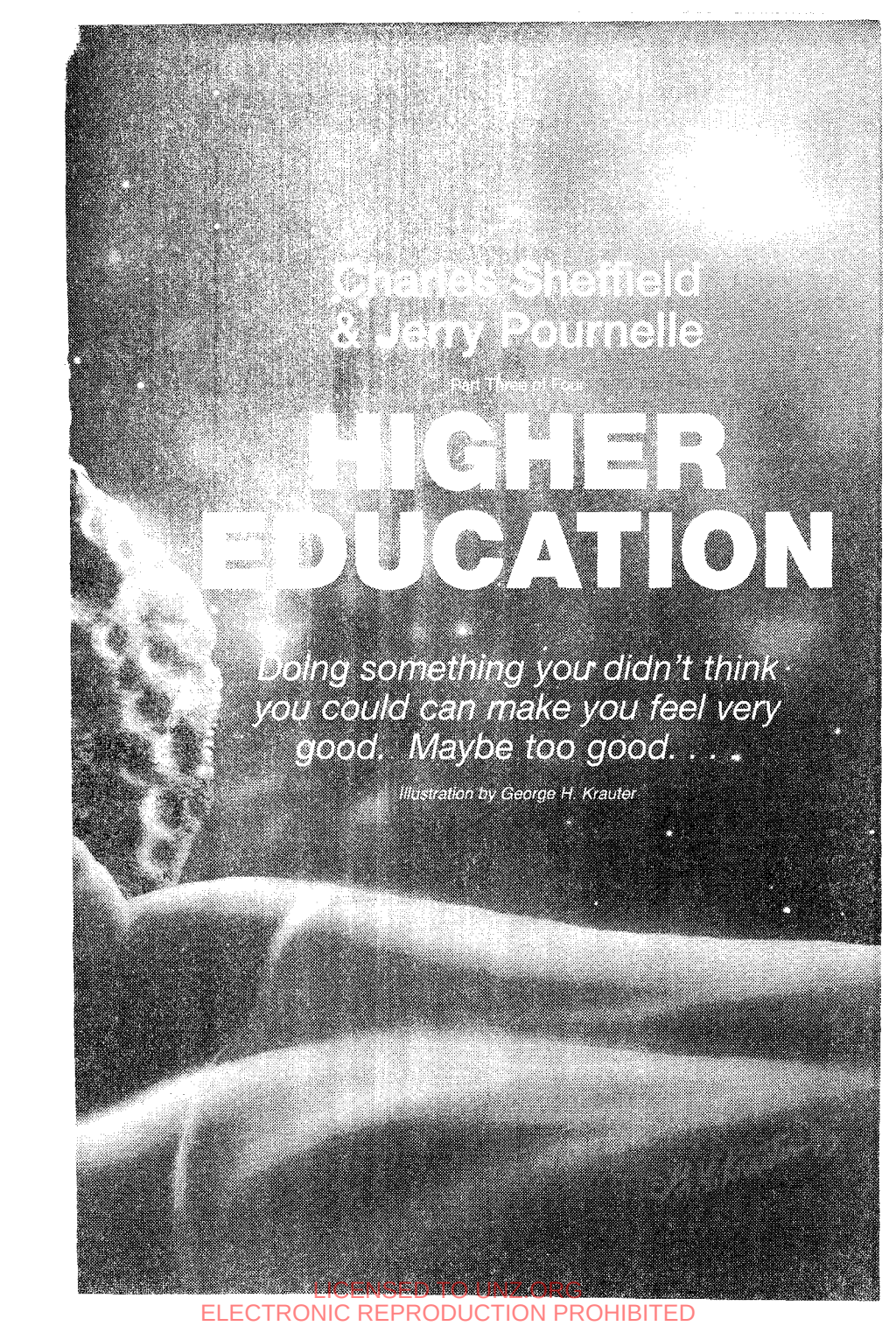
Charles Sheffield
& Jerry Pournelle
Part Three of Four
HIGHER EDUCATION
Doing something you didn't think you could can make you feel very good. Maybe too good. . . .
Illustration by George H. Krauter

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SYNOPSIS

Rick Luban *is a bored sixteen-year-old trapped within an education system that does not care if he succeeds or fails. He knows next to nothing, and his teachers, lacking all authority over the students, have given up on education in favor of trying to keep some minimal level of control.*

Rick is kicked out of school when a practical joke on a new teacher backfires, and catches instead a visiting congresswoman. The usual penalties for student misbehavior no longer apply, and Rick is expelled. He is afraid to go home, since his mother and stepfather will lose the education payment that they receive as long as he stays in the school system.

As he is sitting outside the school he is approached by one of his teachers, **Mr. Hamel**. *Hamel feels some sympathy for Rick, and gives him an address on the other side of town, where a job might be available.*

Rick is given a battery of aptitude tests, and passes. He is offered a trainee position with Vanguard Mining and Refining. However, the job is not on Earth. Rick will be trained to mine the Asteroid Belt, out between the orbits of Mars and Jupiter. Before he can go he will need parental permission. In fact, while he is away all parental authority will legally be transferred to Vanguard Mining.

That is readily forthcoming from Rick's mother and stepfather. The very next morning he has packed his few belongings and is on his way to New Mexico for additional tests and training.

Rick quickly learns that his new job is going to be competitive. Not every new recruit will make it to space. After a hard few weeks Rick learns that he is one of the successful ones, along with **Alice Klein, Chick Teazle,** *and Rick's sworn enemy* **Vido Valdez,** *with whom he has already had one fight. On the flight up from the surface of Earth Rick meets another enemy, or at least an adversary:* **Deedee Mao,** *a tough and aggressive girl from another training camp. They get into an argument, which ends abruptly when they encounter free-fall for the first time.*

As their ship approaches CM-2, **Jigger Tait,** *an experienced space miner who is on his way back to the Asteroid Belt from Earth, points out something else that no one has told Rick and Deedee: Vanguard Mining is not without competition. There is another company, Avant Mining, that is aggressive, fast-growing, and a real threat to Vanguard. Jigger shows them an Avant Mining ship, returning from the Asteroid Belt.*

Once the recruits are installed on CM-2, the next stage of training begins under **Turkey Gossage**. *The true nature of the parental authority exercised by Vanguard Mining becomes apparent: students will not be forced to perform their assignments; but only if they do so will they receive meal tickets for food that is worth eating. Otherwise it will just be oatmeal and vitamins.*

With little real choice, the new recruits settle down to work. They must be able to read and write, and know enough mathematics to solve practi-

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cal problems important in space mining. Rick feels that he is doing pretty well, until one day he makes a dreadful mistake. After one of his practical tests he makes a sexual move on **Gina Styan,** *Turkey Gossage's attractive assistant. She can look after herself, and she knees Rick so hard in the groin that he is convinced that he is permanently injured. He limps away to the CM-2 gymnasium, where he meets Jigger Tait and learns something even worse: Gina is Jigger's girlfriend, something that Rick had no suspicion of before.*

Fortunately Jigger seems more amused at Rick's nerve than upset by his act. He tells Rick that Gina only looked at him in a friendly way because he reminded her of her own kid brother, back on Earth. As for Gina herself, she never bothers to mention the incident to anyone.

Soon Rick has something to take his mind off his gaffe with Gina. Vido Valdez—wrongly—thinks that Rick has made a play for his girlfriend, **Monkey Cruse**. *Actually, Rick has just been trying to help her with her math homework, which gives her special difficulty, but Vido doesn't want to listen to that. They have another fight, which Rick wins because he has been working out regularly in the gym with Alice Klein. He knows how to move in free-fall better than Vido, and takes advantage of that to knock Vido unconscious.*

The next morning Rick is summoned to see Turkey Gossage. He thinks he is in trouble, but learns to his surprise that Vido has told Turkey that the fight was his own fault. Turkey wants to see Rick about something quite different: his final practical test, for which he has been paired with Deedee Mao.

Deedee and Rick still do not get on well together, but Turkey does not offer them a choice. They have to load an ore carrier, take it to the CM-2 refinery, and return—with a tight deadline. As they set to work, they find that Turkey has built in little extra problems, things that will go wrong at every stage. They struggle through loading problems, and drive problems, and doors that are locked when they should be open. Their final difficulty, however, defeats them. They cannot complete the trip outside CM-2, because of an intense solar flare.

They do their best, making part of the return journey inside CM-2, and the rest shielded by the mine's bulk. But they are still six minutes past their deadline, and reach Turkey Gossage knowing that they have flunked.

Turkey tells them that the solar flare was an accident, not intended as part of the test at all. They have actually passed their practical beyond his expectations. All that remains is the final theory paper.

A few days later they struggle with that, and it's a monster. After a tense waiting period, Rick and Deedee learn that they have passed, along with Alice Klein and Vido Valdez and Chick Teazle.

But not everyone has passed. Monkey failed, and Vido blames himself because he asked her not to seek help with math from Rick. Rick says that

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had nothing to do with her failure; Monkey had no aptitude for math at all. No amount of coaching would have allowed her to pass. He manages to talk Vido into going along to the dance that marks the celebratory endpoint for the successful recruits.

Rick is not feeling ready to dance, but Jigger Tait gives him no choice. He leads Rick to Deedee Mao and orders him to get on with it. Rick does—not too skillfully. Part of his mind is still on something else that Jigger said: "Tomorrow the honeymoon's over. No more spoon-feeding."

In a few more days they will head on to the Asteroid Belt. The real training is about to begin.

Part III

CHAPTER ELEVEN

The change predicted by Jigger came sooner and harder than expected.

The trainees had partied all night and collapsed into their bunks at dawn. They were still settling into exhausted sleep when a fist hammered on the door and a loud female voice shouted from the corridor: "Ten minutes to get to the main assembly hall. If you're not there, you won't be going anywhere."

It wasn't Gina Styan or Coral Wogan. In fact, it wasn't anyone whom Rick recognized when he stumbled, still yawning and stretching, into the main hall with the rest of the groaning trainees. The woman waiting for them was tall and big-shouldered. She had black hair and bright blue eyes, and she might have been pretty but for her oddly lopsided face.

She counted and nodded. "You don't know me—yet. And I've seen your names but not your faces. So let's begin with that. I'm Barney French. Start there at the right." She pointed at Chick Teazle, who had been first into the hall. "Each of you state your last name."

As the roll call proceeded she hardly seemed to be listening. But at the end of it she pointed to Vido Valdez. "You. Valdez. You came close to flunking geography on your test. That won't do. You'll be given special assignments to bring you up to speed.

"You, Klein." She pointed at Alice. "Your mathematics is a disgrace. We'll do something to take care of that—or rather, you will. Beverly Landau—"

"It's Goggles, ma'am." Goggles blushed and wriggled, while the others stared at him. "Goggles Landau."

"Isn't your real name Beverly?"

"Yes. But I never use it."

"Why not?"

"Well, it's—Beverly is a girl's name."

"I see." She glared at him. "You mean, it's a girl's name just like Barney is a boy's name?"

Goggles was smart enough not to answer, and she went on, "Well, *Beverly* Landau, I'll call you what I want to. Your parents certainly did. And, *Beverly* Landau, if your test results are anything to go by, the amount you understand about atomic structure could be written on the small point on the top of your head. That's going to change. Agreed?"

"Yes, sir—ma'am."

"Very good. Actually, I prefer sir. Now, Mao." She turned to Deedee. "Is there any special name *you'd* like me

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to call you by?"

"No, sir."

"Good. So let's talk about history. You stated on your general knowledge quiz that Rome was founded in the year 753 A.D. Would you be interested in revising that opinion?"

There was a long silence, as Deedee opened her mouth and then closed it. Finally she said tentatively, "753 B.C.?"

"Correct. A mere difference of fifteen hundred years, but what's that between friends? Bravo. Or is someone else to be congratulated? Was there a little help from a person behind you? You—Luban. Did you tell Mao the right answer?"

"No, sir." Rick had been trying to be totally inconspicuous behind Deedee and Vido Valdez.

"Do you know who did?"

"No, sir." Rick felt his gut tighten. He had just told a direct lie. He had heard Gladys de Witt, on his immediate left, whisper the answer.

"I don't believe you." Barney French studied his face. "But I will let it pass. You are in enough trouble already. For the past two months you have been in a position to look at Earth anytime you chose. Did you do so?"

"Yes, sir. Many times."

"And yet you cheerfully asserted on your final test, despite the evidence of your own eyes, that 70 percent of Earth is land area, while only 30 percent is covered by water."

"I said it backwards." Rick cringed at his own stupidity. "I meant it the other way round, 70 percent water."

"Really? How very reassuring. I suppose you consider it all right to remove oxygen from your suit when you intend to add it. Or perhaps to accelerate your ship when successful rendezvous requires you to decelerate?

"Now listen, all of you." To Rick's relief she turned away from him to address the whole group. "You may be thinking, what the hell is all the fuss about? Barney French is nit-picking on things that don't make a damn of difference. Well if you think that, you're wrong. No matter how much fudging you got away with on Earth, or even here on CM-2, that ends today. I'm not like Turkey Gossage, willing to blow your nose and change your diaper. When you leave CM-2 you leave kindergarten. Accuracy and precision do make a difference when you're out in the Belt. The details *matter.* You have to get things *right.* If you don't believe me, take a look."

She walked along the line of trainees, turning so that they could get a good view of her misshapen face.

"See the scars? See the bone grafts, and the facial reconstruction? Take a close-up. You're seeing me *after* thirty-seven operations and the best plastic surgery that money can buy. My body is in worse shape than my face—I have more metal than bone in my shoulders. And I'm one of the lucky ones. Four people died in the accident that did this. And do you know what caused it? One lousy plus sign that should have been a minus, in one small subroutine that controlled one phase of a continuous casting operation on CM-24. The man who made the error paid for it. You probably saw plenty of horror videos when you

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were back on Earth. But you've never known real horror, until you see what a pressure jet of molten steel does when it hits a human body in low-*g*."

She stared at and through the hushed group of trainees. "You will see simulations of accidents just like the one I was involved in—but not today. So you can go now. Pick up your assignments as you leave. Each of you will find your name on one of the packets. I want all the work done in the next three days. What each of you is required to do reflects your individual weaknesses, plus one additional question that you must all try to answer. Cooperate as much as you like—but remember, you get no credit if you spend your time helping somebody else, and then screw up on your own work. You're not trainees any more. You're *apprentices*. Earn that title.

"Oh, yes, and one other thing. I don't think you want to open those assignments right now, because we'll be lifting from CM-2 in four hours. Pack your bags, and say your fond farewells. Anyone who wants to go to the Belt should be at the main port by eleven hundred hours."

CM-2, so alien two months ago, felt like home now. Rick had his few belongings packed in ten minutes, spent another hour wandering the familiar exercise rooms, dining hall, and dormitories, and then fifteen minutes on his bunk examining the packet that he had been given by Barney French.

He stared in dismay at the contents. He was tired out, nervous, and about to enter the new environment of a ship heading for the Belt. But somehow he was supposed to tackle these assignments and finish them in the next three days.

Your knowledge of Earth geography is inadequate. Read the following—pages of references. Tons of reading, for someone who still had to mouth out most words of more than two syllables.

Your lack of knowledge of the Belt and the Solar System is deplorable. Learn the following by heart. Sheet after sheet of data about the planets, asteroids, rings and moons of the Solar System, endless names and numbers and lists and computer file references.

Back in school he had never been forced to learn things by heart. That was dismissed by the powers-that-be in the Earth education system as "rote learning," old-fashioned and restrictive and undesirable. It didn't leave a student with what Principal Rigden always called "time for smelling the roses."

Rick didn't recall smelling many roses. He did know he had spent a lot of time watching the tube.

Not any more, though. No tubes, except as video outlets for education and training modules. He suspected he was going to see plenty of those.

He puzzled over the final question, the one given to all the apprentices: *Estimate your ship's travel time to the Belt. Tables of the coordinates of the destination, CM-26, as a function of time, together with an initial position of the starting point, CM-2, will be found in this packet. You may assume that there will be continuous acceleration and deceleration on the journey at one-quarter of a standard Earth gravity. Answers within 10 per-*

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cent are acceptable.

Rick groaned to himself. Absolutely baffling—he didn't know how to do orbital mechanics. Hell, he couldn't even spell the words.

Just yesterday he had been on top of the world, now it was back to the same old grind, only worse. He would force down some breakfast—he still believed what he had told Deedee, an active brain needed food—then he would head for the main launch port.

Jigger was right. The honeymoon, if it had ever started, was over.

With an hour or more to go 'til eleven, the main port was already crowded when Rick got there. He had seen ships come and go from CM-2, and as part of the practical course the trainees had been given a guided tour around one of them; but he had never examined any ship the way that he studied the *Vantage,* waiting now for its passengers and crew.

The ship was huge, ten times the size of the transfer vehicle that had carried the trainees from low-Earth orbit out to CM-2. Most of it, though, was the drive. The living quarters would be a tight fit for the forty passengers and crew. Rick walked over to the point of closest approach to the main engines of the *Vantage,* and stood staring up at them. They were Diabelli Omnivores, a linked ring of a dozen blue cylinders, each about four meters across and forty meters long. Within them, deuterium and helium-3 would be fused. The heat produced by that raised the main propellant, hydrogen, to a temperature of more than a million degrees.

Naturally the Omnivores were never used close to any other object. Smaller ion rockets surrounding the main drive ring provided for maneuvering and docking. The main engines were called *omnivores* because with some modification they could fuse any of the lighter elements up to neon. It meant that the *Vantage*, like her sister ships *Vanquish* and *Vanity,* could find suitable fuel anywhere in the Solar System.

It also meant that in the hottest fusion mode the internal temperature would reach a billion degrees.

"Close your mouth, Rick." Deedee's voice came from right next to him. "You're an apprentice now, not a trainee. You're not supposed to gape."

He turned. Apparently two hours sleep agreed with Deedee. She was bright-eyed and full of bounce. Rather than look at her he pointed up at the Omnivores. "We'll be sitting right on top of those monsters. If something goes wrong with the drive, we'll never even know it. Might as well be in the middle of a supernova. How come you're not as worried as I am?"

"Maybe I am. Maybe women just know how to fake things."

"Yeah. But you never gave me a chance to find out about that."

Although Rick kept his tone light, there was a hidden bitterness in him. Apparently Deedee thought nothing unusual had happened the previous night. But it had. After a couple of hours of dancing, Rick had suggested that he and Deedee go off together, just the two of them, and find someplace quiet. He spoke casually, as though it was no big deal, which was the way you handled these things.

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That didn't mean it was, though.

And she had declined.

"Not tonight, Rick. Tonight I want to dance 'til I drop. But if I did go with anybody, you're the one I would want to go with."

She had known very well what he was suggesting, but she had hauled him back onto the dance floor. Her answer left him horny and restless. The way she had put it he was not supposed to feel rejected. He did. But he wasn't going to let her know it, then or now.

There was a stir among the people at the far end of the chamber. Looking that way, Rick saw that an entry port to the front part of the *Vantage* was opening. A light ladder was scrolling out and reaching down to ground level, though in such low gravity it was hardly necessary. Every one of the apprentices could jump to hit the port blindfold. Some of them were already moving forward toward the ladder.

"Wait for it!" Barney French's roar came from the entrance to the chamber. "Didn't you lot ever hear of discipline? Apprentices stay there. I have to be first up so I can assign quarters—unless you all want to sleep on top of each other."

She came soaring over their heads and went through the port dead center. Just behind her flew Jigger Tait and Gina Styan. It was news to Rick that those two were taking a ride out to the Belt on the *Vantage*, but he was delighted to see them.

"All right!" Barney reappeared in the port. "Come on. All aboard that's going aboard. Girls first!"

Her last words were lost in a burst of laughter. Chick Teazle, too impatient to wait for her to finish, had jumped before she got to "girls first."

Once you were launched in low *g* there was no way to stop yourself. Chick floated upward, waving his arms and legs uselessly. Barney waited until he reached the port, then reached down to grab his foot and boosted. He went spinning away right over the top of the ship, to Barney's raucous, "There you go, Miss Teazle."

It was new proof that the trainee group still had tricks to learn in space. Rick waited his turn, right after Goggles Landau, then bent his knees and jumped. It was a point of pride to hit the exact center of the port, and he did it.

Barney French didn't seem to notice. "Luban, 24-C," she said. "To the right. Keep moving."

To the right meant toward the front of the ship. Rick floated his way along a cramped corridor with bare metal walls. He had expected that 24-C would be a dorm, and was surprised to find that he had a tiny private room. It held a terminal, a small cabinet up near the ceiling, one chair, and a bed that could be opened all the way only when the chair was folded up into a recess in the wall.

Rick took from his bag the picture of his mother. He had sneaked it out when he left home, and been ashamed to show it back in the dorms of New Mexico or CM-2. Now he placed it on top of the data terminal. Everything else in the bag went into the cabinet. After that there was nothing to do.

Barney French had told him to

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come to 24-C, but she had not ordered him to stay there. He went back into the corridor. Vido Valdez was heading toward him. He did not seem nearly as unhappy as he had been yesterday, when he learned that Monkey had failed. And Rick had seen him close-dancing late in the evening with Gladys de Witt.

So much for undying love.

Since people were still coming aboard the *Vantage*, Rick headed the other way, toward the bows of the ship. The corridor ended in what looked like a food service area, with little tables that could be folded out of the walls. It would seat no more than eight people. Beyond it was another corridor, even narrower. Rick eased his way along it, and found himself at last in a tiny round chamber with a curved and bulging transparent wall.

He was in the very front of the ship, staring out at the blank metal facade of the main port floor and wall. As he watched, he heard a series of clanging sounds from behind him followed by the slow rotation of the ship. The port floor was deserted. Rick decided that the ship must now be sealed, and the external pressure would be dropping toward zero so that the docking facility could be opened to space.

And he was still here, sitting in the bows. Shouldn't he be somewhere else, safely strapped in before the *Vantage* began to move?

Then he realized that the ship *was* moving, so gently that he had not noticed it. He was looking out at the starscape beyond CM-2.

He leaned back, overwhelmed by two thoughts. First, he realized the enormous difference between moving *to* space when you left Earth, and moving *through* space, which is what they were doing now. To get into space called for powerful thrustors and high accelerations, and you were wise to strap yourself in. But once you were here, even the gentlest acceleration was enough to move you around and no special precautions were needed when you started.

Second was the sudden knowledge: *they were on the way.* Earth was visible over on the right-hand side of the transparent bubble. When he had first looked at it from CM-2 it had seemed so far away. But in the next few days it would shrink from a whole round world to a tiny pale dot, no brighter in the sky than Venus or Jupiter. Hundreds of thousands of kilometers of distance would gradually turn to hundreds of millions.

Rick stared at the little blue-grey marble, and made a decision that surprised him completely. He had been pleased to leave Earth, and he couldn't wait to get to the Belt.

But one day, some day, he would come back.

CHAPTER TWELVE

The training course on CM-2 had been tough. It was hard for Rick to believe that anything could be worse. During the first horrendous days of travel to the Belt, he learned that he was wrong.

The difference, in one word, was "yourself." Where Turkey had listened patiently to questions and provided answers, Barney French did no such thing.

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"What do you think I am, your bloody nursemaid?" she said, when Rick went to her with an innocent question about siliceous asteroids. "That's what data banks and computers and hypermedia systems are for. They know a thousand times as much about planetary compositions as I do. Look the damn thing up for *yourself*. And while you're at it, check out siderophilic ore refinement. You're going to need that, too."

Instead of an answer, Rick found himself thrown out with an additional assignment. It was hard to avoid Barney French in the ship's cramped interior, but he quickly learned to do it. Sarcasm was her favorite mode of expression, and each time you met her she loaded another task on top of your heap.

DIY—Do It Yourself. Within twenty-four hours it became the motto of the apprentices. One of the first things that Rick had done for himself was to look up the word "apprentice," which he had heard of only vaguely back in school. He found it defined as a "person under a legal agreement to work for a master craftsman in return for instruction and support."

Nothing there about working at a terminal until your eyes popped out of your head and your brain was ready to turn to watery gruel and trickle out through your nose. All the same, he liked the sound of "master craftsman." The suggestion was that you could eventually be one yourself.

Rick hid away in his cramped cabin and buckled down to his assignments. After the first few hours of stately recession from the Earth-Moon system there was little to see from the *Vantage*'s observation ports, and nothing to do inside but eat, sleep, and work.

He realized very quickly that there was no possible way he could complete all his assignments in the time available. Two months ago he would have thrown up his hands in despair, turned his back on the whole thing, and guaranteed his own failure. But he was learning. Nobody in the Universe could know everything. Therefore, everyone made choices. Success might be no more than the right choice—plus a little bit of luck.

He examined the list of what he was supposed to do, and decided that the geography of Earth would be invaluable—to someone about to go there. He was heading in the opposite direction. The most important things for him to know were about the Belt. After that he could tackle other planets and moons, and if there happened to be any time left over he would worry about the rest. Not only was it logical to start with the Belt, but he knew from experience how much easier it was to learn about something in which you had a personal interest. Back in school, even the dullest idler had no trouble following the lessons about masturbation and sexual foreplay.

And what about the other problem they had been set, to estimate the travel time of the ship to the Belt? On the face of it, that was absolutely impossible. He would have to learn all sorts of orbital mechanics, for a body moving under the gravitational influence of the Sun and the Earth and who knew what else. And yet it was totally out of

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character for a question to be asked that a trainee had no chance of answering. . . .

Rick put the problem to one side. Instead, he tracked computer references and pulled up the Belt data bases. He found that this piece of the assignment was actually fairly interesting. He had heard the word "Belt" thrown around many times since he signed up, and it brought to mind a tidy construct of sizable planetoids orbiting the Sun in some well-defined and neat region of space. But the reality was more like a disorganized swarm of objects, some bodies dipping in their motions closer to the Sun than the Earth, some as they moved around the Sun also rotating about each other like miniature Earth-Moon systems. The main region of the Belt, between Mars and Jupiter, occupied a trillion trillion cubic kilometers of space. The bodies ranged in size from whole worlds like Ceres, a fifth as big across as the Moon, down to small pebbles and grains of sand.

From the point of view of Vanguard Mining, neither the very small nor the very large were apparently of interest, except to be avoided. The big ones did not permit Vanguard's proprietary mining methods, which would be revealed to the apprentices when they were out in the Belt; the smallest ones were simple navigation hazards. The payoff lay in medium-sized bodies between half a kilometer and two kilometers across.

Even there, composition was important. Some asteroids were 99 percent silicon oxides; in other words, they were just lumps of rock. But others were mostly metals, valuable iron and nickel and platinum and iridium. If a body was really high in metals, mining it was relatively easy—compared with *finding* it in the first place. You couldn't send a prospecting ship to one little body after another, until you found the one that you wanted by taking material samples from it. That would be too slow and expensive. Instead, the exploration technique called for instrument surveys in which a body's reflected light was measured from a distance in many different parts of the spectrum, then matched with predicted reflectance curves for different mixtures of metals and rocks. Only after that work was all done on the computers did it make sense to send a ship to a promising asteroid and stake a claim.

For the first time, Rick understood what Jigger Tait had been talking about when he grumbled about Avant Mining. Recently, the Vanguard staff had found, again and again, that when they sent a ship to an asteroid Avant Mining had beaten them to it and already staked a claim.

Just how did Avant or Vanguard mine an asteroid, once they had mining rights? Rick was all set to follow the data bank pointers and try to find an answer when he halted in mid-command. He had just been told that the Vanguard mining method was proprietary. Chasing information about it would be a pure waste of time. And time to waste was one thing he surely did not have.

Rick sighed, erased his query, and turned to the next piece of his assignment: learning the names of the major

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bodies in the Belt, together with their size and composition.

Within a few minutes he realized that the new task was mind-bogglingly boring. It was a relief to be interrupted by a soft tap on his door. He half-expected it to be Deedee, and he was all set to treat her with the coldness that he felt she deserved. But to his surprise it was Alice Klein.

"Mind if I come in?" She still had that shy little girl voice, but he noticed that she did not wait for his answer before she entered.

"What do you want?" He remembered Barney French's warning: Help someone else with their problem if you like, but don't think for one moment that it will get you off the hook with your own assignment. "I don't have time to talk, I'm really busy."

"That makes two of us." He had the only seat, so she moved to sit on the edge of his folded bunk, as languid and graceful as ever. "I'm not here to pick your brains, Rick. At least, not just for that. I want to suggest that we work together on a problem."

"Which one?" Rick knew from what Barney French had said that Alice still had problems with math. He didn't, at least so far, which meant that working with her would be a one-way street.

"The problem we all have. The time it will take us to get to CM-26, out in the Belt. Have you looked at that yet?"

"Not yet." Rick's skepticism increased. To tell the truth, he had mentally given up on the problem. It didn't just call for straight learning of facts. You had to understand loads of math and orbital equations, which even Gina Styan admitted was a job for specialists. He wasn't sure where to start. "Do you know how to do it?"

It was a question designed to get rid of her. He was convinced that Alice would have no idea. She would admit her ignorance, and then he'd ask her to go away. But she was pursing up her mouth and wrinkling her nose.

"I don't know." The grey, wide eyes focused on Rick—for the first time, she seemed to be looking *at* him and not *through* him. "Back when we were studying for our theory test, Turkey Gossage told me something that he said I ought to keep in mind for future reference. I have, but I don't know what to do with it. That's why I came to you. You're smart, you can see through things."

She was praising him, buttering him up. Rick knew that, but still he was pleased. Flattery, even when you recognized it, made you feel good. Maybe because it showed somebody thought you were *worth* flattering.

"What did Turkey tell you?"

"He said that the Sun's gravity controls the movements of every body in the Solar System."

"Big deal. We all know that."

"Yes. But he went on to say that the real surprise was how *small* the Sun's gravitational force is. For instance, he told me that if you work out the acceleration on an object at Earth's distance from the Sun, you find that it's less than a thousandth of a *g*. And when you get out to the Belt, it's less than one ten-thousandth of a *g*."

"So?" But Rick already had the conviction that Alice was on to something.

"Well, we were told to assume that

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this ship is accelerating at a quarter of a *g*."

"I believe that, it certainly feels about right."

"But that means once we get well away from Earth, the gravity forces from Earth and Sun and every other planet are nothing, compared with the ship's own acceleration. I feel sure this is relevant to the problem—only I don't see how to use it."

"But I think I do! Give me a minute." Rick sat staring at nothing. If all other accelerations on the ship were hundreds of times smaller than the ship's *own* acceleration—

"Alice, we don't need to know a whole slew of orbital theory. Our own ship's acceleration is so high, we can get a good value for our travel time by assuming that we travel in a straight line and ignoring everything else. All we need is our own acceleration, and the distance we have to go."

"But we don't know the distance—CM-26 keeps moving."

"Sure it does." The boredom and frustration had been swept away by excitement and certainty. Rick suddenly had a clear mental picture in his head. "See, here's what we do. We make two tables. The first has two columns. It shows times, say, every hour from the time we started, in the left column. The right column shows the distance from CM-2, where we started, to CM-26 for the corresponding time. It has to be a table, because CM-26 keeps moving. The information to make that distance table comes right out of the coordinates given to us in the problem packet."

"But we don't *know* the travel time—that's what we're supposed to find out!"

"I know. Let me finish. Now, we make another table. This one also has two columns. The left column is the same list of times, in hours. The right column says how far the ship goes in that much time, assuming that we accelerate for half the time, and decelerate for the other half. We already had the formula in class for the distance traveled in a given time with a given constant acceleration. It's just half the time multiplied by the final speed."

"But we don't know the final speed!"

"Yes we do—at least, we know the formula for it. We had it on a test, it's just the acceleration multiplied by the time."

"If you say so. But I *still* don't know what we do next."

"We're almost finished. We have two time/distance tables, right? Now we plot them both as curves on one graph. The first curve is the distance to CM-26, hour by hour. The second curve shows the ship's distance traveled, also hour by hour. Those two curves cross somewhere—they have to, or we'd never be able to reach CM-26. And the time where they cross is the travel time—our answer. It's the time when the ship will have gone just far enough to reach the position of CM-26. An approximation, but I bet it will be closer than 10 percent."

Alice was shaking her head. "You'll have to go through all that again. You went too fast for me. Say it one more time."

"I'll do more than say it—we'll do it, together. You make the table for the

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distance to CM-26. I'll make the table for ship's distance traveled. Then we compare and make the graph. Here's a calculator for you."

While Alice began to work out distances to CM-26, Rick began to make the table for ship's distance. The result made him whistle in astonishment. A quarter of a *g* didn't sound like much of an acceleration, compared with the five *g*'s and more that they had briefly endured on the way up to low-Earth orbit. But keep it going, and the results were amazing. After an hour of accelerating and another of decelerating, you had traveled over thirty thousand kilometers. No big deal. Increase that to two days, though, and you were eighteen *million* kilometers away from your starting point. And in eight days. . . .

"Alice, I want you to check this and see if I'm screwing up somewhere."

"What's wrong?" She had been working steadily, sitting on the folded bunk and biting her lip in concentration. Now she paused and smiled at Rick. For a change, the smile involved her whole face. Looking at her it was hard to believe that she usually seemed remote and uninvolved.

Rick held out his calculation. "According to this, if we travel for eight days we'll have gone almost three hundred million kilometers. We'd be out in the Belt!"

"Let me look." And, as she quietly did her own calculation, "You know, nobody *said* the trip out would take weeks and weeks—we just assumed it. Maybe that's the point of the problem we were all given."

"You mean, they want to see if we can figure out for ourselves that we're going to be there sooner than we thought?"

"That's right. You know what Turkey told us. The zingers wouldn't stop when we left him." She studied the final number on her calculator. "I get a different answer—twice as big as what you said."

"Let me take a look." Rick studied what she had done. "You weren't listening to me. You've accelerated the ship for the whole eight days. You can't do that. Look at your final speed, it's nearly seventeen hundred kilometers a second. You'd go right through the Belt like"—Rick paused; *like shit on skates* was what he had been about to say, but he couldn't see that expression pleasing Alice—"like lightning," he finished weakly. "You have to *accelerate* for half the time, then *decelerate* the other half, so you're not going fast when you get there."

"Let me do it again." She repeated the calculation, slowly and carefully, and nodded. "I agree with you now. Four days accelerating at a quarter of a *g*, then four days decelerating, takes you about two hundred and ninety million kilometers."

"That could be more than enough to get you to Ceres." Rick decided he sounded a bit like a know-it-all, and added, "I was just learning the asteroid distances when you came in."

Instead of replying Alice got up from the bunk, went across to the door, and locked it. She came back and stood directly in front of Rick. "You've finished the problem, everything but comparing the two tables."

"You did it, too. I had no idea where

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to start. You brought me the key information."

"But I'd never have figured out how to use it without you. You provided the brain power, not me. My question is, what now?"

"I don't know what you mean."

"Do we keep this to ourselves?"

Rick hadn't thought about that, but it didn't take long to reach a decision. "Of course we do! Barney French said we could cooperate, but she didn't say we had to. I don't know about you, but I need all the extra credits I can get. There's no reason to share what we've done with everybody else."

"With *anybody* else?"

"With anybody else."

"Good." Alice motioned for Rick to stand up, and quietly folded his chair into its niche in the wall. "It's a deal, then. Our big secret, just the two of us. I like that." She studied his face, alive with excitement at the work they had just done together. "And I like you, Rick. I watched you dance the other night, and I wished that you were dancing with me."

"I didn't realize that."

"No reason you should. I didn't have the sense to come over and ask you, did I?" Alice stepped out of her shoes and calmly began to unzip her suit. "So I'm asking you now. If you're willing, Rick, I'd like to seal our bargain."

Her body was slim and supple, with translucent skin that showed a fine tracing of veins on small, firm breasts. As she slipped her dark-blue suit down over her shoulders and hips, all of Rick's unrelieved horniness came roaring back. He began to fumble with his own clothing as Alice, naked, unfolded Rick's narrow bunk and turned to look at him.

"I was going to ask if you had any interest," she said, "but I guess I don't need to." She lay down on the bunk and stretched luxuriantly, her legs long-muscled and slim and dusted with fine golden hair. "Come on, don't leave me alone here."

Rick moved to lie on top of her—he had little choice as to position; the bunk was not wide enough for two people. As her arms and legs went around him and their bodies met, he had a brief memory of Deedee saying, "If I did go with anybody, you're the one I would want to go with."

Well, Rick told himself defiantly, she had only herself to blame. He didn't owe her anything. If Deedee had treated him nicer, maybe he'd be behaving differently today.

And maybe not.

Alice's warm breath was on his neck, and she was murmuring little grunts of pleasure into his ear. Her body was moving beneath his, squeezing and sliding and tightening on him in a way that he had never experienced before—not with Juanita or Celine, or with any of the other "sure things" he had tried back in school.

Alice didn't make love like a schoolgirl. She made love like a woman, a knowledgeable, experienced woman. Rick shivered at what she was doing to him. She seemed to know exactly what would excite and please him most.

How had he ever thought of her as

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a sexually immature little girl? Well, never again.

Two hours later they were still entwined. Alice had moved to lie on top of Rick, and he had his eyes closed. When he felt her lift her upper body away from his, he grunted in complaint and murmured, "What you doing?"

"Checking the time."

"Why? Who cares?"

"I do." She lifted off him all the way and swung her legs down to the narrow space beside the bunk. "Either I go now, or I starve. I'm assigned first mess sitting today. How about you?"

"Second. Is it that late already?" Rick opened his eyes and watched Alice as she pulled her suit up over her body. Just to look at her started getting him excited all over again. "Will you come back here later?"

She slipped on her shoes, bent over to give him a quick kiss on his bare chest, and said, "Can't do it tonight. I'm scheduled for time on the math instructor."

"When, then?"

"Tomorrow?" She unlocked the door and peered outside. "Nobody there, but you ought to get dressed, too." She came back and gave him another and longer kiss, this time on the mouth. "I hate to go. You're a great lover, Rick, and today was wonderful. But we can't afford to flunk. You ought to work tonight, too."

"I will." Rick watched her go out and close the door, then lay back on the bunk. He didn't want to get up, and he didn't want to work. He wanted to lie here and relive the past couple of hours.

The months since he left school had been filled with surprises, but nothing as surprising or exciting as Alice. To think that he had known her since the first bus trip from Albuquerque airport, and not really known her at all. He had never suspected that her face could flush so with passion, and those wide, grey eyes could look at him as though she was ready to devour him.

A soft chime over the ship's central communication system brought him out of his reverie. It meant that first mess was beginning, and if he wanted to eat at second sitting he had just twenty minutes to get up, dress, and make his way to the little food service area. When he had first seen it, he had never imagined that it might be the only place to eat on the whole ship. But it was. The apprentices ate there in relays.

He dressed slowly and folded away his bunk, then paused for another look at the time/distance tables that he and Alice had generated to solve the problem of travel to CM-26. After dinner he would go over their work again, but he was not worried. What they had done had the right feeling to it, the feeling that you couldn't describe but also couldn't mistake. Once you hit on the right method, a problem suddenly became ridiculously easy. It seemed like a general truth: what you knew was easy; what you didn't know was hard.

Rick wandered slowly along the narrow corridor to the mess area. He had never felt so good in his whole life. He arrived just as the first sitting apprentices were getting ready to leave and

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dumping their plates and cups in the hopper to be vacuum cleaned. Alice was at the table nearest to Rick. He walked over to her.

She stood up, turned toward him—and hurried past him as though he did not exist. Before he could think of what to say she was out of the room. He took two steps after her, then paused. Deedee Mao was entering, blocking the way, walking right up to Rick and smiling at him.

"The first person here again. You got a tapeworm, or just hollow legs?" She frowned at him. "What's wrong, Rick? Are you feeling all right?"

"Yeah—I guess." Rick slumped down bewildered at one of the tables. What was going on with Alice? Why had she cut him cold like that, after what had happened between them? "Yes, I'm fine."

"Well, let's see what tonight's mystery is. I'm getting fed up with squid pie." Deedee sat down right opposite Rick. The people assigned to different sittings changed all the time, but they all went through the same ritual. You were served an anonymous lump of something for the main course, and you guessed what it might be. The winner was the one who came up with the most imaginative—usually rude—suggestion.

Tonight, though, Rick didn't feel in the least like playing the game. He didn't even want to talk, although it was obvious that Deedee was in a chatty mood. He did his best to reply normally but she started to look at him strangely across the table, her smiles changing to frowns. It was a huge relief when somebody else bustled in, sat down next to Rick and said, "All right if I join the two of you?"

The kid was someone Rick had never seen before, although up to this point he had thought he knew every apprentice on board the *Vantage*. Somebody must have been added at the last moment. The skinny newcomer had a tousled mop of curly light-brown hair and a fresh, ruddy complexion, as though he had just come in from a brisk walk in the open air. He grinned at Rick and Deedee, stared down at the plates that were appearing from the server, and said "Deviled dingo dong again, I see."

Rick just stared. It was Deedee who stuck out her hand across the table and said, "Hi. We've never met before. I'm Deedee Mao."

"Tom Garcia." The kid smiled at her and turned expectantly to Rick.

"Rick Luban." Rick held out his hand in turn, and then, with no idea what to say next, added, "How are you doing with your assignment?"

It sounded inane, and felt even more so when Garcia put his head to one side, pursed his lips, and said, "Dunno. I guess if we get to CM-26 in one piece I'm doing all right."

"Huh?" Deedee's face reflected Rick's own confusion.

"Maybe I should have been more informative during the introductions." Tom Garcia waved his arm around him. "You see, it's my job to fly this thing."

"You mean the ship?" asked Deedee. "You're the *Vantage*'s *pilot?*"

"I'm afraid so. I hope it's not too big a disappointment for you. Actually, I'm one of two. The other is Marlene

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Kotite, and she's holding the fort right now while I'm here feeding my face."

"But you look younger than I do!"

"So they tell me." Garcia shrugged. "I'm sorry, but what can I do? Wait twenty years, I suppose, and it will take care of itself."

"But the seniority system—" Deedee began, then stopped herself. "I guess everything out in the Belt is so new, there aren't any really senior people."

"That's partly true. More to the point, it's not like the transportation system back on Earth, set in stone. Out here, people who are best at the jobs get them." Garcia shook his head. "I'm sorry, that sounds like I'm boasting. I didn't mean to."

"You have every right to boast. You're in charge of this whole ship!" Deedee's attention was no longer on Rick, and he didn't mind that at all. "Would you mind if I asked you some questions," she went on. "About the ship, I mean."

"Ask away. Only two conditions. First, you've got to give me time to eat. Second, I won't tell you anything that might give you an advantage over the other apprentices on the travel time question that Barney French set all of you."

"No problem. That's completely impossible anyway. Everybody agrees—no one will get an answer." Fortunately all Deedee's attention was on Tom Garcia, otherwise Rick's face might have given him away.

"If the Diabelli Omnivores can fuse any element lighter than neon," she went on, "Why do you use a deuterium/helium-3 mixture? Turkey Gossage told us those are rare materials, hard to obtain in large quantities."

"Quite true. Two reasons. First, all the fusion products except for neutrinos are charged particles, so the Omnivores can direct them all in the same direction by using electromagnetic fields. That gives a very efficient drive. If I need to I can accelerate the *Vantage* at a couple of *g*'s. If we fused carbon or oxygen we'd be down to a fifth of a *g* or less. Second, fusing heavier elements requires much higher temperatures, up in the billion degree range. That means more wear and tear on the engines, and much more frequent maintenance. For a working ship, the fraction of time in service is one of the most important variables."

Rick listened to everything that the pilot said, but half his mind was somewhere else. He could not get Alice's strange behavior out of his head. As soon as the meal was over he slipped away, leaving Deedee still fascinated by what Tom Garcia had to tell her.

He was not sure where he would find Alice, but he went wandering aft toward the women's quarters. He received odd looks from half a dozen female apprentices as he went, but at last he located her where he might have expected—in the tiny exercise room, running doggedly on the treadmill.

"Alice!"

"What?" She gradually slowed the pace to zero, and stood there with her chest heaving.

"You ignored me back there. I wondered why. I mean, I didn't do anything."

She glanced across at the door. "Not here. We can't talk here."

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"Why not?"

"I'll explain later. Go back to your room."

"But I want to—"

"I'll see you there in fifteen minutes. Now *go*—this second."

Rick retreated along the corridor to his room. He unfolded his bunk and sat down on it, baffled and upset. When Alice arrived at last, closed the door, and locked it, he glared at her.

"First you tell me how wonderful it was together, then half an hour later—"

"Rick." She came across to him and kissed him firmly on the lips. "We should have talked before I left for dinner. Do you want a job with Vanguard Mining, or would you rather be kicked out and sent back to Earth?"

"That's a dumb question. You know the answer. What does it have to do with you and me?"

"Everything. Vanguard has a very simple operating philosophy: the company comes first. One sure way to fail is to put emotions and personal feelings ahead of the company and your job."

"Alice, I *don't* put my feelings ahead of the training. But what you and I do is really important to me."

"Of course it is. And to me. And it's allowed to be." She sat down next to him on the bunk and put her arms around him. "There's a very easy way to have the best of both worlds: Do what you like, but *don't let it show*. Do you have any idea how many affairs were going on back in the New Mexico training camp, or on CM-2?"

"Vido and Monkey?"

"That, and a dozen others. But people had enough sense to keep things to themselves."

"Jigger and Gina—"

"Did you realize they were an item, until the party on the final night?"

Rick shook his head. He had known all right, but he certainly didn't want to tell Alice just *how* he knew. And she was quite right, his own pass at Gina had taken place *because* he didn't know about her and Jigger.

"I wasn't going to say anything or do anything in the mess hall," he protested. "I was just going to talk to you."

"Yeah, sure. Talk to me. You didn't see your face. You big simpleton." She hugged him close, to take the edge of what she was saying. "Anyone who saw you looking at me would know in a minute what you and I had been doing. You couldn't have made things any clearer if you'd written my name on it and left it dangling out of your pants."

Instinctively, Rick looked down at himself. "I can't help the way I feel."

"Nor can I. But we have to be *discreet*. We can't afford to moon around looking lovesick. What we do in private is one thing. But don't expect me to act anything but cold and distant when we're in public. We run enough risk of being found out without adding to it."

"I don't see a risk. No one is going to come in here when the door's locked. How could anyone possibly learn what we do and use it to cause trouble?"

"Oh, Rick, Rick, Rick." She leaned back against him. "You are a real sweetheart, but you're a hopeless optimist. How could they learn about

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us, you ask? Let me name one way. Suppose you got me pregnant."

Rick sat bolt upright. "You're not—you can't be—are you?"

"I'm not. But no thanks to you. I took care of things. But I sure didn't see you practicing any *coitus interruptus*."

"Huh?"

"Don't worry about it. It's an awful idea. Anyway, I'd have killed you if you'd tried it. But you see what I'm getting at. We both think it's important to succeed with Vanguard Mining, and we don't want anything to ruin our chances. So when we see each other in public, it has to be polite formality—just the way it was between us one day ago."

"What about in private?" He was running his hand lightly along the curve of her thigh.

She turned to stare at him. "Oh, all right. Just for half an hour." She sighed. "You're an animal, you know. I don't know if you've listened to a word I said. I ought to have guessed what would happen when I said to meet in your room." She pushed him back until he was lying flat on the bunk. "Remember, formal in public. In private, though, you get to do absolutely anything you feel like—and so do I."

CHAPTER THIRTEEN

Rick was convinced that no one else would solve the problem of the ship's travel time. It was a shock when at the end of the third day Barney French announced that a total of six people had obtained the right answer.

She did not, however, provide the names.

"You know who you are," she said to the assembled group. "This isn't a school. My job isn't to give out prizes."

Which left Rick to stare around and wonder who was so smart. Chick Teazle? Gladys de Witt? Vido? Not Deedee, if what she had told Tom Garcia was the truth. Had a whole group of them cooperated, without telling the rest? Not judging from their expressions. It seemed to him that everyone was staring round at everybody else.

Barney also offered no public comment as to how people had managed on their individual assignments. She simply called them in later, one at a time, asked a few questions and made barbed comments on the answers, and piled on the work load.

"You'll need this, and this, and this," she said calmly to Rick. He didn't argue, but he knew that each item she dropped on him meant four or five hours hard work. It made him wonder why he had been so keen to succeed when he was on CM-2.

He carried his assignments back to his cabin and started the grind. The next couple of days were endless labor, broken only by food, sleep, and stolen hours with Alice. Barney French had dumped on her even harder than Rick. Alice had only just squeaked through the finals on CM-2, and still she was barely making the grade. Rick felt almost guilty at the time they spent together—but he never suggested that they might stop seeing each other. Lovemaking with Alice provided the bright spots in a sea of drudgery.

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Halfway point came and went, a few minutes of weightlessness while the *Vantage* turned end-over-end. Deceleration began. Four and a half more days, and they would be at their destination in the Belt.

Seventy-two hours after turnover Rick, wandering along to the dining area dazed by an excess of work and sex, found himself sitting opposite Deedee. She stared at him in a sad-eyed and accusing way, but all she said was, "How you doing, Rick?"

"Fine." Did she know? How could she know? He had not spoken a word to anyone, and after the first day he had been careful not even to look at Alice in public.

He pulled out of his trance and made a big effort. "I'm fine," he repeated. "How are you doing?"

"Busy. Working hard. Thinking a lot. About a lot of things."

Their food had not yet appeared, but she stood up and went to another table. Rick felt uncomfortable, though he told himself that he had certainly not done anything to Deedee. She kept looking at him from where she was sitting at the other table.

He wolfed his food down as fast as he could and returned at once to his cabin. It was late and Alice had told him that she didn't think she would be able to make it until the next day, but he really wanted to see her and touch her and talk to her.

He was lying on his bunk, supposedly learning the table of the elements but actually drifting and dreaming, when it happened.

An urgent voice spoke over the general announcement channel. "Emergency. Please return at once to your cabin and secure all movable objects. Lie on your bunk and strap yourself down. In five minutes we will perform a major course change and move to high acceleration. Repeat, this is an emergency."

Rick glanced around the little cabin. The chair was tucked away in the wall. He went across to the terminal, grabbed the picture of his mother, and locked it away in the high cabinet. As the announcement was repeated—this time he recognized Tom Garcia's voice, nothing like as casual as usual—he went back to the bunk, lay down, and secured the straps across his body and legs.

Now what? The terminal came on without his touching it, something he had not realized could be done. Barney French's image appeared on the ceiling above Rick. He realized for the first time that the terminal could also serve as a back-lit projector, throwing an image onto the flat plane of the white ceiling.

"To repeat what our pilots told you," Barney said quietly, "we have an emergency situation. Let me assure you that this is not what you apprentices refer to as a 'zinger,' part of a planned test. Since Tom Garcia and Marlene Kotite are otherwise occupied, I have agreed to tell you what we know so far. Fifteen minutes ago we received word from Headquarters of a major accident on one of our advanced mining facilities, Company Mine 31. There are casualties. We don't know yet how many. After the initial message from CM-31 there has been no communication of any kind. Because of

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the changing geometry of our mines in the Belt, the *Vantage* happens to have the best location and velocity vector of all our vessels to reach CM-31 in minimum time. We will shortly change direction and go to our maximum acceleration of a little more than two *g*'s. That will be maintained for four and a half hours, after which we will perform turnover and decelerate with equal force for six hours. We anticipate that accommodation changes on board the *Vantage* will be necessary upon our arrival at CM-31, but I cannot yet inform you of what those might be.

"I know that each of you has experienced much higher accelerations than two *g*'s, but only in physical tests or for the short period of an ascent to orbit. Do not experiment. As soon as our thrust pattern has stabilized, I and others familiar with high-*g* shipboard activity will come to each cabin in turn and instruct you on safe operations until we reach CM-31. Meanwhile, remain in your bunks."

The screen went blank. Rick lay back and waited. There had been no sign of the usual sarcasm in Barney French's voice, but also no room for compromise on her face. Anyone who left his bunk, that look said, would be in major trouble. Something terrible must have happened on CM-31, though Rick could not imagine what.

Ten minutes ago he had been brooding over Alice's absence. Now he was glad that she had not been able to come to him. Were other apprentices struggling right now into their clothes, and scrambling back to their own cabins?

The drive turned off. There was the usual moment of disorientation as his stomach came up to meet his throat, and then the giddiness of a rotation and realignment of the ship in inertial space. Before that could become uncomfortable he was pressed back hard into his bunk. Wrinkles in the mattress and blanket that he had never noticed before made their mark on his back.

He had been told not to move from his bunk, but he was free to move within it. A set of controls for the terminal lay on the bunk's right-hand edge, so that if you wanted to you could work the data banks while you were lying in bed. Rick keyed it now, with difficulty, adjusting to the use of fingers that suddenly did not want to lift from keys.

COMPANY MINE 31—at last it came—ONE OF THE NEWEST OF VANGUARD MINING'S ASSETS, THE BASE ASTEROID FOR CM-31 HAD AN ORIGINAL FORM CLOSE TO A TRIAXIAL ELLIPSOID WITH SEMI-MAJOR AXES 0.9, 0.7, AND 0.5 KILOMETERS. . . . What was that supposed to mean? Nothing at all, so far as Rick was concerned. He plowed on, word after unfamiliar word. . . . ALTHOUGH SMALL COMPARED WITH OTHER MINES SUCH AS CM-8 AND CM-20, CM-31 IS UNUSUALLY VALUABLE BECAUSE OF ITS HIGH CONTENT OF SIDERO-PHILES. . . .

Siderophiles. Rick swore. That term again, the one Barney French had told him to check out—and he hadn't done it.

He could hear sounds from outside his door, but no one came in. He had to be quick. He moved to the word-

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search data bank, and the definition appeared on the screen.

SIDEROPHILE: LITERALLY, IRON-LOVING. IN MINING OPERATIONS THE TERM REFERS TO A GROUP OF ELEMENTS THAT COMMONLY OCCUR IN THE PRESENCE OF IRON AND ARE PREFERENTIALLY REMOVED WITH IRON DURING AN EXTRACTION PROCESS. THE MOST IMPORTANT OF THESE FOR COMMERCIAL PURPOSES ARE NICKEL, IRIDIUM, AND PLATINUM.

So CM-31 was a potential gold mine—or at least, a platinum mine. Rick switched back to his other data file.

. . . CM-31 FORMS A TEST SITE FOR NEW LARGE-SCALE CENTRIFUGE AND ZONE MELTING METHODS. IT IS BEING USED IN PROOF-OF-CONCEPT MODE FOR SUCH MINING TECHNIQUES. . . .

Centrifuge was what they had done to him during the physical tests, spinning him around on the end of a long arm with a balance weight at the other end, faster and faster, until he blacked out. He didn't see how you could put a whole asteroid on the end of anything.

Zone melting made even less sense. It was another phrase that meant nothing. He went again to his on-line dictionary and this time met with less success. The data base defined what he wanted as a method of purifying certain metals, but after that it quickly became gibberish: "The zone melting process relies on the fact that many impurities prefer to remain in the liquid phase rather than freeze out into the solid phase. A melted section propagating along an otherwise solid body will collect impurities in the moving melted section. They will be swept along and concentrated at one end."

Rick puzzled out the message, word by painful word, and was as mystified when he finished as when he started. *Concentrated at one end.* One end of what? An asteroid didn't have ends, the ones he had seen were all irregular roundish lumps.

. . . IN VIEW OF THE HIGH METAL FRACTION OF CM-31, A RECORD 99 PERCENT OF THE TOTAL MASS (ROUGHLY 8 BILLION TONS) CAN BE EXTRACTED. IT WILL BE TRANSFERRED TO CIS-LUNAR SPACE EMPLOYING A SMALL PART OF THE DROSS AS REACTION MASS FOR LOW-THRUST ION PROPULSION UNITS.

Dross. Rick swore again. What the devil was dross? The trouble with learning was that the more you learned, the more you realized how much you didn't know. Once you started you were on a neverending treadmill and you couldn't get off.

The opening door ended his frustration. It was Barney French herself, panting hard. "Luban? Up out of the bunk." She caught sight of the screen display. "Good choice—let's hope you don't need that for a while. Don't rush getting up. Slow is smart, first time you do it."

Not just the best way—the only way. Rick came gingerly to his feet and stood there swaying. Tom Garcia had said two *g*, but it felt more like ten.

"You'll get used to it." Barney was reading his mind. "All of you have

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been spoiled the past couple of months by low-*g* environments. This is nothing. Think yourself lucky you didn't sign with Avant Mining and have to live with pulsed fusion. Their high-acceleration mode takes them from two and a half *g*'s to zero and back every few seconds, all day long. You ever try to eat dinner bouncing on a pogo stick?"

She moved to the door without waiting for an answer, and Rick followed her out of the cabin. He paused on the threshold. The passageway, along which he had often zoomed with so little effort, had become a deep vertical well. Handholds and footholds that he had never noticed before were placed every foot along it.

"This is the seventh time I've done this," Barney complained. She looped a thick soft rope around her waist, tied the other end around Rick under his armpits, and motioned for him to start down. "Make me an old woman before my time, it will. Go on, start down. I'll be right behind you. And *go slow.* You use both hands and both feet, and three of those must work to support your weight at all times. Did you ever go rock-climbing back on Earth?"

"No. No rocks where I lived."

"That figures."

"I did a few night climbs, though. Up and down the outside of buildings." Rick still shivered when he remembered the jump from the roof of the Lafferty apartments to a balcony on the building next door. Only eight feet, but when you stood in the dark waiting, ten stories up, eight seemed more like eighty.

"Dumb ass." Barney sniffed, a few feet above him. "Risking your neck for nothing. Trying to impress some girl, I bet."

"No." Rick was climbing down the shaft, slowly and carefully, a boulder strapped to each arm and to his back. If he fell, Barney was supposed to hold him until he could grab another handhold. But could she do it? She'd have to hold up four times her own weight. "I was just trying to prove I was brave," he panted.

"And did you?"

"I don't think so. I proved I was scared." Rick had no more breath for talking. He could see now why Barney had been struggling for breath when she came into his cabin. But he was almost there, reaching the solid floor of the little dining area.

"Take your time," said Barney. "You won't need to do much of this unless we have an emergency, but you have to know how ahead of time—just in case."

Rick nodded a head made of solid lead. He turned, making sure that his feet landed in the correct place—and found himself staring into Deedee's anxious face. Goggles Landau was next to her.

"Message from the flight deck," said Goggles at once. He was talking not to Rick but to Barney French, now on the last step of her own descent. "Pilots Garcia and Kotite want you there as soon as possible. They have more news."

"Shoot. I've got one more still to do. Anybody know where Teazle's cabin is?"

"I do," said Rick and Deedee simultaneously. They stared at each other.

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Her cheeks darkened with a blush, and she glared defiantly at Rick.

"Good." If Barney noticed, she did not care. "Landau, you come with me. I have a job for you. Mao and Luban, I showed you how to climb. Now you go and show Teazle—I want *all three* of you roped together when you do it. Understand?"

"Yes, sir."

"I'm putting a lot of trust in all of you, more than I should in an apprentice. Don't let me down."

"We won't." Rick and Deedee stared at each other as Barney and Goggles left the dining area for the lower level between passenger quarters and drive units, where the flight deck was located.

"What do you think happened on CM-31?" Deedee asked.

Rick jumped at the chance of a neutral subject. He was forced to put his arms around her to tie the rope, and it was the closest they had been since the night of the dance. Her figure was a lot fuller than Alice's. He was trying to avoid contact with her breasts, but he couldn't help brushing against her.

"I'll make a guess," he said. "They were using new mining methods. Something went wrong while they were melting and separating the different metals. CM-31 is mostly metal, iron and nickel and platinum."

She didn't ask how he knew, merely nodded and started to climb. He followed close behind. Going up was harder work than going down, but it was also easier. You could see just where your hands had to go, instead of groping around with your feet.

"Do you know what centrifuge melting is?" he asked, after they had climbed about five meters.

"Sure." She was breathing heavily, but moving up steadily. "It's a confusing term—two different things in one. It means melting, plus centrifuge separation. You take a cylinder filled with different materials, and you melt them. At the same time you spin the cylinder around on its axis. That gives you like a gravity gradient, but of course it's not gravity, it's centrifugal force. The denser liquids go to the outside, farthest from the axis. The light ones stay close to the middle, sort of floating on the heavy ones. So you've separated them out from each other. The dross floats at the very center."

"Dross?"

"Scum. You know, the light useless stuff."

The long speech had taken all her breath, and she paused in her climb. Rick, focused on the placement of his own hands and feet, took an upward step and ran the top of his head into something soft.

"Oof! Do you mind?" Deedee sounded exasperated. "That's my rear end you're poking. It's off limits."

"Sorry. Not the first time you've called me a butt-head, though." Rick waited, until she began to move upward again. "What happens if you don't have a cylinder available?"

"Then you can't do centrifuge melting, can you? Why are you asking?"

"The data bank says CM-31 was testing centrifuge melting methods. That's why I said I guessed that something went wrong when they were trying to do it."

They had finally reached Chick Tea-

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zle's cabin, tucked away up near the very front of the *Vantage*. Deedee knocked and went in without pausing.

"Hey there!" Rick heard Chick, loud and self-confident as usual. "This is an unexpected treat. Let's get"—Chick saw Rick at the door, and his voice changed on the final word—"friendly."

"Barney French sent us." Deedee sounded abrupt and unnatural. "Get up from your bunk. We have to show you how to climb down to lower ship levels."

"Why you two?" Chick stared at Rick.

"We happened to be there with Barney." Rick held up the thick rope. "We have to be all tied together, just in case."

"I don't need no damn rope." But Chick took the end that Rick handed him, looped the rope around under his arms, and tied a deft knot. "All right, go ahead. I'll follow you down."

"No." Rick put his arm on Deedee's, just as she was about to start the descent. "You go first, Chick. That way if you fall, we'll be above you and have a chance to brace ourselves. If you were above us you could knock us with you."

"I'm not going to fall, you dummy." Chick glared at Rick, but he moved forward. "What happens if you fall on me?"

"You cushion my landing." Rick watched as Chick started down. He was long-limbed and powerful, and he moved with a speed and confidence that Rick envied. Deedee followed, saying what Rick was thinking: "Slow down a bit, Chick, or you'll pull us off-balance."

Chick grunted, but he did as she asked. The three descended steadily, to find Barney French waiting for them back at the dining level.

"Good," she said. "Everyone has been through the drill. Now you do it without the rope. I want each of you back in your own cabin, and on your own bunk until we get to CM-31."

It seemed such an anticlimax that they all stared at her instead of jumping at once to do what she said.

"Can't you tell us more about what happened?" asked Deedee.

"I propose to do exactly that. But I'm not going to go round telling you one at a time. Get to your bunk, or you'll miss the beginning."

It was incentive enough. Chick went swinging away up the vertical passage like a monkey, while Deedee started downward.

Rick, about to follow right behind Chick, felt Barney's hand on his arm.

"Give him a few seconds," she said. "If he does goof, I assume you don't want two hundred pounds plummeting down on you under two *g*'s."

Rick waited impatiently, staring up but ready to jump out of the way, until Chick vanished into his cabin. Then he made his own ascent, trying to strike the balance between speed and caution. Barney was right. Practice made all the difference. Already it felt easier than the first time.

He lay down on his bunk, fixed the straps into position, and waited impatiently for something to happen. What had Chick meant when he said, "Let's get friendly"? And why had Deedee suddenly turned all stiff and weird?

Rick could guess, but before he had

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time to brood on it Barney's image was again projected on the ceiling.

"I told you during our very first session that when you came aboard the *Vantage* all the babying ended," she said. "Well, I lied. This phase of your training is supposed to place you in what we call a Level Three environment. Unfortunately, the situation at CM-31 represents a Level Five environment—the highest level of danger and uncertainty that fully-trained staff ever expect to meet. You are not ready for that, but needless to say this was not from choice. Headquarters have again confirmed that every other ship in the fleet will need at least thirty-six hours more than the *Vantage* to reach Company Mine 31. That time could be the difference between life and death. Therefore you, the apprentices, must assist in operations. When we reach CM-31 you will supplement six experienced staff members: myself, Tait, and Styan; Garcia and Kotite, our pilots; and Skipios, our engineer.

"Meanwhile, in the nine hours remaining until our arrival at CM-31, you are all to remain in your bunks. If you can sleep, do so. First, however, I am going to give you background on where we are going and what we will find there."

It was far into the usual rest cycle and Rick was tired out, but the idea of sleep while in a two-*g* field sounded like pure fantasy. The slightest movement made you aware of your body. Even breathing was an effort.

"Here is CM-31," Barney went on, "as it was when our original prospecting team arrived and confirmed the nature of the find." Her face vanished, and was replaced by the image of an irregular and pock-marked lump of rock. Rick knew that the Belt held billions of similar mountain-sized boulders. Without knowing this one's composition there was no hint that it might have unusual value.

"Now for a few basics," Barney went on. "Gravity is the force that defines the whole shape and movement of the Solar System—the Galaxy, too, if it comes to that—but for objects the size of the one you are looking at now, gravity is a very weak force. It is just strong enough to pull small particles of material into contact with each other, but if gravity was all that held CM-31 together, you'd be able to mine it and the other asteroids with a spoon. But when the dust and grains of sand and pebbles meet, a different form of bonding takes over. The little particles *sinter,* which means that they all stick together to form a single mass. And that mass doesn't come apart easily. You can think of CM-31 as we discovered it as a ball of iron, with some rock and small fractions of other metals. It's solid, and it's hard, and if you want to break a bit off you have to do it with a chisel.

"It's strong enough that it would still hold together if you started to rotate it around its principal axis of inertia, which is the most stable way to make it spin."

The lumpy surface of CM-31 now showed dozens of bright points of light all around it. They were drive units. Rick could not tell if this was a simulation or the real thing, but the body began to turn, slowly at first and then gradually faster.

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"You can rotate it pretty fast, and the body will still hold in one piece," Barney's voice said. "But that's not true if you also *heat* it. We use electric induction, which will produce internal currents to heat the body all the way through. If you did that until CM-31 melted, and it was also spinning, it would just fly apart."

The image on the screen showed the dark planetoid beginning to glow a dull red. It slowly deformed to the shape of a thick plastic disk, then suddenly disintegrated and was gone, parts flying away in all directions.

"Obviously, that's no way to mine an asteroid. You'd lose the asteroid itself, and you'd lose valuable drive units. It's also not what people imagine, when they think of the word 'mining.' You might ask, what's the point of heating and spinning a body, when you could just as well mine CM-31 the way most of the mines, like CM-2, were done? Remember the tunnels in CM-2? Mining machines made those, dug ore, and brought it out from the interior.

"The answer to my question, in one word, is economics. It's far less expensive if you can melt and refine and process a whole asteroid, in one swoop.

"And you can. Here's how.

"First, you place a cylinder in position around the whole body."

CM-31 reappeared, just as it had been at the time of discovery. Now a huge silvery cylinder appeared from nowhere and gradually swallowed the whole asteroid into its open end. When the body was totally engulfed, the open end of the cylinder irised shut.

"There's a couple of things to notice about that cylinder," said Barney. "First, if you look very closely you'll see drive units spaced at intervals around the curved part. On the cylinder, *not* on the asteroid. They will make it spin around its central axis. Second, you can't see them but there are also hundreds of induction field generators on the cylinder. They will heat anything inside by induced eddy currents. They will also, if the cylinder is rotating, make the asteroid inside start to rotate through an electromagnetic dragging effect. Keep that up long enough, and the material inside will melt. When it melts, it will be thrown outward to the wall of the cylinder.

"One other thing, and this you can't see: the cylinder is made of the strongest material we know, dislocation-free carbon filaments. It remains strong at high temperatures. It will contain the materials inside it, even when everything is spinning around the cylinder main axis at high speed."

Rick could see what was coming next, he had known it the moment that the cylinder appeared. The fact that he really owed his knowledge to Deedee did nothing to lessen his pleasure. He could imagine her, tucked away in her own bunk, hugging herself in satisfaction. She had got it exactly right.

"I assume you can all see what's coming next," said Barney's voice, taking away Rick's sense of superiority. "As everything rotates, the liquid metals press outward on the cylinder wall, the heavier ones toward the outside and forcing the lighter ones closer to

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the axis of rotation. Actually, it's not quite as simple as that, because some metals form eutectic alloys that don't separate by centrifuging, but the general principle is valid. The heaviest metals are tapped first, from spigots on the outer circle of the circular ends of the cylinder. Then we run out the lighter ones. Finally all that's left behind is a low-density layer of melted rock and sand. With a really high metal content asteroid, that's not much more than a froth. We empty that, too, and leave it behind in space, all that remains of the original asteroid. At that point, the empty cylinder—after a bit of scrubbing and servicing—is ready to move on and tackle the next mine.

"I'm sure you're asking, what went wrong in processing CM-31? If I could answer that, I would tell you. But I don't know. We're moving closer as fast as we can, and a few hours from now we'll be able to take a look. Until then I suggest that you all rest, even if you don't think you can sleep."

Barney French stopped speaking. The projection unit remained alive, throwing onto the ceiling an image of the cylinder, drive units flaring, spinning hypnotically. Rick watched and watched, until at last he slipped into a half-trance. He was neither asleep nor fully awake. He was aware of a time of freefall, when the *Vantage* turned end-over-end and began its deceleration, but he could not have given an estimate as to how long it lasted. It seemed long after that when the thought came into his head that it should not be necessary to watch a simulation. By now it might be possible to see the real CM-31.

He roused himself and tapped the code for Barney French's cabin. There was a risk that she was sleeping, but somehow he doubted it.

"Yes?" The answer came at once.

"This is Luban."

"I know. I can see your call ID. Why aren't you sleeping?"

"I can't. I want to ask your permission to climb up to the front of the ship and use the scope there to look for CM-31."

"You may not be sleeping, but your brain is turned off. We passed turnover a while ago, so we are now *decelerating*—which means that the front of the *Vantage* is pointed directly *away* from our destination. You'd see nothing." And, while Rick was feeling like a prize buffoon, "You are the fourth person to call and ask me that, so I suppose it's a general concern. There is no observation port down toward the stern, but there are imaging sensors. Stay where you are. I'm going to hook the output of the rear-pointing sensors into the terminal display. You'll have a chance to see CM-31 at the same moment as the pilots. Don't expect anything for a while."

The projection on the ceiling above Rick flickered through a kaleidoscope of random color swirls, then settled to show a stationary star field. A blue icon at the upper left of the image blinked "target zoom." There was an impression of impossibly fast motion as stars moved toward the scene edge and disappeared. The image became increasingly grainy, until at last the words "maximum magnification" replaced the first icon.

Rick peered, and saw nothing but

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fuzzy points of starlight. The scene was steady now, but as minute followed minute he noticed that one point of light at the outside edge of the image area was creeping slowly across the screen. That was not a zoom effect. The moving point had to be a substantial asteroid. It was close to the *Vantage* compared with everything else, but it could not be CM-31. The ship's telescope would surely be aimed to place the mine at the center of the field of view.

He focused his attention on that middle area, and was finally rewarded by the sight of a central point of light that came and went at random. The sensitive detectors of the ship's imaging system must be picking up and displaying single photons. It was their first sight of the target mine.

Rick settled again into a near-trance. He did not think that he slept, but he did close his eyes occasionally. Each time he opened them there was a little more to see. Over minutes and hours the vagrant point of light gradually steadied, to become a pale silver dot, and then a blurry round disk. Soon the ship's optics made an adjustment, trading magnification for contrast. It was possible to discern that the disk had a slight asymmetry, longer top to bottom than it was side to side.

Fifteen minutes more, and there was no doubt. Rick was looking at an oblong shape, longer than it was wide. It must be the mining cylinder enclosing the ore body of CM-31. But it was not the smoothly spinning regular figure shown in the simulations. There was a definite slow wobble to its motion, and part of the curved surface seemed darker than the rest.

"We have established contact with a maintenance module associated with CM-31." Tom Garcia's voice brought Rick's attention away from the growing image. "Signals indicate two survivors on board the module. We have no indication of survivors on the main mining habitat. The module is running very low on air. The *Vantage* will end deceleration and achieve rendezvous in fourteen minutes. Personnel stand ready for emergency stations."

"You heard that." The distorted cylinder of CM-31 vanished and was replaced by Barney French's impassive face. "Over the next ten minutes I will assign an emergency station to each apprentice. Do not—repeat, *do not* go to those stations until I tell you to do so. In thirteen minutes we will change from our present deceleration to a near-free-fall environment. Remain in your bunk until that time. Once we are in free-fall, unstrap yourself, make sure that you are dressed in regulation fashion, and remain in your cabin. Be prepared to move at once when I tell you to do so. Do not worry if you hear nothing more from me for the next few minutes. I will be addressing each one of you individually."

CM-31 appeared again, close enough for a clear image to fill the projection screen. Rick was looking at a distorted shell, wobbling slowly around an off-center axis. A long split ran almost from end to end, revealing a dark interior. It looked as though the cylinder had burst, buckling outward. Where were the billions of tons of metallic ores that had been inside it? Where was the maintenance module,

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with its survivors? He could see no sign of it—no sign of anything resembling a ship or a life-support habitat. What had happened to the rest of the miners on CM-31?

"Luban," Barney's voice said suddenly over the intercom.

"Yes, sir."

"Do you know the location of Port A-3?"

"Yes, sir."

"You will go there when we move to free-fall, without waiting for further instructions. Put on a suit, and take your subsequent orders from Tait or Styan. Understood?"

"Yes, sir."

"Any questions?"

"No, sir." Rick had a thousand, but this was no time to ask them.

"Very good."

The intercom fell silent, leaving Rick in a ferment of nervousness and speculation. He had been in a suit often enough, that was not a problem. Some other fear—of dying, of failure, of loss of nerve—was tying his guts in a knot.

The image was still on the screen but he took little notice. He was mentally rehearsing, over and over—unstrapping himself, hurrying out of his cabin, swinging his way down to Port A-3. *The module is running very low on air.* That part of Tom Garcia's message didn't need explanation. The speed with which the crew of the *Vantage* acted could be the difference between life and death.

Free-fall—sooner than expected. Rick was off his bunk and out of his cabin in seconds. He realized at once that his mental rehearsal was totally useless. He had missed the obvious—that a score of other apprentices would be scrambling through the same narrow passageways, all heading for different destinations.

He eased past Goggles Landau, past Skip Chung, past Lafe Eklund, all heading in the opposite direction. Chick Teazle, by some miracle, zipped past Rick going in the same direction. Deedee Mao and Alice Klein were standing together in the dining area, obviously waiting for somebody. Rick nodded at them and zoomed on, down to the lower ship level where Port A-3 was located. Vido Valdez was already there, working his way into a suit. Rick was oddly pleased to see him—he trusted Vido, maybe more than any other trainee. Rick put on his own suit and they went through the thirty-six point sequence together, checking suit seals and functions.

Before they were done, Jigger Tait arrived. He was already in his own vacuum suit, complete with mobility pack.

"Radios on?" he said. And at their nods, "Good. I don't expect you'll be going outside, but if I need help I'll holler. Here." He handed each of them two squat oxygen cylinders. "Hang on to these, and stand by for cycling."

They were clearly in emergency mode. The air pressure dropped three times as fast as usual, and even before vacuum was established the outer lock was opening. The remaining air puffed away. Rick, floating with the security of an anchor line, realized that he was at the very edge of open space. The deformed cylinder of CM-31 hung in front of him, huge and somehow ominous.

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"There they are," Jigger said. "Spitting distance. Hats off to Tom Garcia and Marlene Kotite. Be ready with the oxygen and wait here."

Without another word he was away, jetting toward a small crab-shaped vessel poised in space no more than two hundred meters from the *Vantage*. Rick and Vido stood and stared. Five more suited figures were leaving the ship from some other exit lock. They all wore mobility packs. One of them was heading for the maintenance module, the other four were jetting off in the direction of CM-31's cylindrical hulk. It was impossible to make individual identification, but everyone moved in space with the confidence and economy of long space experience.

Jigger and one other person had reached the crablike maintenance module and were entering on its under side. Within seconds they had reappeared, each holding a suited figure. They jetted at once toward the *Vantage*. If they had said one word to each other, it was on a frequency not received by Rick and Vido.

They reached the lock, and Rick saw that the other person was Gina Styan. Still without a word, she and Jigger grabbed oxygen cylinders. They attached them to the suits of the two new arrivals. Jigger peered in through the visors. The eyes of the occupants, both women, were flickering open.

"All right," said Jigger. "We sure cut it fine. I'm going to cycle the lock so we can flush carbon dioxide, but there's no rush on that now."

One of the women was giving him a weak thumbs-up sign.

"I'd better get back out there and secure the module," Gina said. "Then I'll see if they need any help over at the main facility."

Rick peered past her out of the open lock. He saw what he had expected to see, the little maintenance module and beyond it the massive cylinder of CM-31. But there was something else. Off to the left, small but steadily growing, was a feathery plume of brightness.

Should he mention it, or would he seem like an idiot? He glanced at the others, and realized that Vido had seen it, too. They stared at each other, and said in unison, "What's that?"

"It's a ship," added Vido. "Isn't it?"

"Can't be," Jigger said. He was still busy with the two survivors of the accident. "Not for another thirty-six hours."

"But it is." Gina had looked where Rick pointed. "It's not one of ours—it's an Avant Mining vessel."

Rick told himself he ought to have realized that. He had seen such a feathery exhaust before, the result of the pulsed fusion drive used by Avant. But it was so unexpected, out here far from anywhere.

And then he realized that it should not be unexpected at all. This was the very place where you might think to meet an Avant Mining ship—out in the broad region of the valuable metal-bearing asteroids.

The other ship was closing steadily, heading right for the *Vantage*. Rick heard a voice in his headset.

"This is Morse Watanabe, captain of the Avant Mining vessel, *Scarab*. We happened to be in a compatible orbit, and we picked up a Mayday signal on

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a broad frequency band with these coordinates. Do you need assistance?"

Jigger Tait and Gina Styan said nothing. It was Tom Garcia's voice that sounded in the headsets. "Thanks for the offer, *Scarab*. As you can see, we've had a major accident here, but everything seems to be under control."

"Glad to hear it." There was a pause, then Watanabe continued, "Unless proprietary elements are involved, would you tell us what happened?"

"We are still in the process of determining that. However, it seems certain that the integrity of the containment cylinder was breached, suddenly and violently. The melted ore spewed out into space in all directions. Unfortunately, the main crew habitat was impacted and destroyed."

Rick heard a grunt in his headset. It came from one of the two women picked up by Jigger Tait and Gina Styan. This must be their first direct evidence that their friends and coworkers were dead.

"I am truly sorry to hear that," Watanabe said. "Any idea what caused the rupture?"

"Not yet. We are working on it. Our preliminary assumption is impact by another body."

"That would have been my guess. Lots of material in this region. Something pretty big, that somehow got past the radar." Watanabe sighed. "Again, our regrets and sympathy. Since we can't help, we'll be on our way."

The feathery plume of the *Scarab*'s exhaust appeared again. The other ship slowly receded. Rick watched it until it was no more than a tiny spark of light, no different from one of the silent stars.

The incident had changed his whole view of Avant Mining. It was a terrible shock to hear Jigger Tait, cycling the lock to fill it with air, mutter to himself, "That slimy bastard. 'Regrets and sympathy'—like hell."

"They were just trying to help," protested Vido. "Weren't they?"

"You can think that if you like." Jigger glared at him, and the two rescued women did the same.

"If you hadn't come along in time," one of them said. "We'd have been dead in another hour or two. With no survivors, CM-31 would have been a derelict. The *Scarab* would have taken possession and filed for full or partial ownership."

"And they'd have got it, too," growled Jigger. "That's space law. Watanabe can say he's glad that things are under control here as often as he likes, but I'll never believe it. He's been robbed of a big gain, and he knows it."

"But the ore's all gone," Rick said. "It was thrown all over the place by the accident."

"Not the ore. That's not what Watanabe wanted. He was after *technology*." Jigger jerked his thumb at the hovering cylinder. "Avant Mining has nothing like that. They still mine using the old bore-and-scoop method. There's nothing they'd like better than a good look at the inside of CM-31. The general technique may sound simple, but the details aren't. Watanabe's out there now, gnashing his teeth—and wishing that the whole lot

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of us had died on CM-31."

CHAPTER FOURTEEN

The two survivors quickly came back to normal health; the bodies of the dead, such as could be found scattered within ten thousand kilometers of CM-31, were given decent space burial; the *Vantage* continued on at a quarter *g* to its original destination; and Rick thought that the whole awful episode was over.

He was wrong. The worst was still to come.

It began late on the second night, when someone slipped into his cabin without knocking. He was lying awake in his bunk, and he sat up pleased. Alice had told him that she had an evening session scheduled for a review of drive mechanisms with Tom Garcia, and would not be able to pay Rick a visit. Something must have changed.

The person who entered was Deedee Mao. "I have to talk to you," she said.

"If it's about—"

"I was told not to talk about this to anyone. But I have to. It's eating me up inside."

She sounded desolate and desperate, in a way that Rick had never heard before. He started to say something, decided that it was a bad idea, and made room for her beside him on the narrow bunk. "I'm listening, Deedee. But if you promised not to talk. . . ."

"It's a promise I can't keep." She drew in a deep breath. "Do you know what I did when we got to CM-31?"

"I think so." They had all talked about their roles in the hours that followed. According to Barney French, they had performed better than anyone could have expected. Each of them would receive a note of praise in the record. "You went over near the main cylinder, didn't you? With Marlene Kotite."

"That's right. We were really there to look for bodies. I was picked because I was once in a bad accident myself, and I've seen some pretty gruesome stuff."

"I didn't know that."

"There's a lot we don't know about each other, Rick. That's a pity." She tried to smile at him, and failed. "Anyway, we found one part of the work crew habitat, smashed to pieces by flying jets of molten metal. Seven bodies. They made me feel like throwing up, because they were in pieces. We had to hunt for arms and legs and heads and try to put them together. Two of them were so badly burned I couldn't tell if they were men or women."

"That's terrible, Deedee." Rick put his arm around her shoulders. "I had it easy, but I didn't know it. I didn't have to deal with anything like that."

"I haven't got to the bad part. We came to one bit of the habitat that had been smashed open by flying metal, and then somehow sealed itself back together. It was airtight, but molten iron had splashed all over the place. We found a man there. He was alive."

She paused. Rick, sensing that it was not the time to speak, waited sympathetically.

"He was alive," she went on at last, "but he had no right to be. The iron had burned him, head and body. He

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must have actually sat for a while in a pool of molten metal. When we found him he was conscious. I didn't know what to do, but Marlene crouched down beside him. 'You're safe now,' she said. 'I'm Marlene Kotite, pilot of the ship *Vantage*. We'll have to move you, so I'm going to give you a shot to knock you out first.'"

"He turned his head toward her. I can't say he looked at her, because his eyes had been burned out. They were just black pits in his head. He had no nose.

" 'Thanks, Marlene,' he said. 'I'm Trustrum Keck, chief mining engineer of CM-31.' He sounded absolutely calm and rational. They say that bad burns leave you like that, in shock but not in pain. 'Before you knock me out,' he said, 'how about a little damage assessment?'

"She looked at me, as if she wished I wasn't there, then she said, 'We met once before, when I was piloting the *Vanity*. It's not good, Rusty. Your eyes have gone, and most of your face.'

" 'I guessed that,' he said. 'And there's more, isn't there?'

" 'Yes. You've lost the flesh of your legs, and your penis and testicles. And most of your right hand.'

" 'I noticed,' he said, 'when it happened. It doesn't feel so bad now.' He was quiet for about half a minute, then he said, 'No chance of real repairs. I don't like the look of the future, Marlene. I want to exercise my option.'

"It was her turn to go quiet, but eventually she said, 'You're in deep shock, Rusty. This is no time to make that decision.'

"But he just gave a sort of coughing laugh and said, 'Tell me a better time. You've seen me,' and after a minute she nodded.

" 'Hold on a little,' she said. 'I'll give you a shot, but I've got a young apprentice with me. She happened to be on the *Vantage* when we picked up your Mayday.' Then she turned to me, and said, 'Step out for a few minutes. Into the corridor.'

"I did. I was totally confused, but it was an order. After about ten minutes she came out again. She had taken off her suit helmet, and her face was dead white. She told me it was all right, I could come back in. I did. He was lying there. He was dead. When I asked what had happened she just shook her head. Rick, she killed him. I know she did. She murdered him."

"No." Rick was suddenly very thankful for the conversation he had had with Jigger Tait, back in the shielded radiation chamber on CM-2. "You can't look at it that way, Deedee. Would you want to live with no eyes and legs? No genitals, no right hand."

She flinched against his arm. "I couldn't bear to!"

"Nor could I. And nor could he. You heard him say it, he wanted to exercise his option—his right to die."

"But that's murder!"

"Back on Earth it is. Out here, it's a fundamental right. Mine, yours, Barney French's. Nobody can take it away from us. And Marlene Kotite couldn't take it away from Rusty Keck. She just did what he wanted, and helped him along a little. Wouldn't you do as much for me, in the same situation?"

"Oh, Rick, don't say that. Please, don't *ever* say that." Then Deedee was

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silent for a long time, so long that Rick thought she must be angry. Finally she patted the arm that he had placed around her, and said, "God rest his soul. Thanks, Rick. Thanks an awful lot. I owe you a big one. But I knew I could count on you. I always can."

She left. Rick lay again on his bunk. He was very glad that he had bitten back what he had wanted to say when she first came in: "Chick Teazle is the one you're screwing, not me. If you want to talk to somebody, why don't you go and find him?"

Rick didn't know the answer to his own question. But he offered up a prayer that he had not asked it.

The final arrival at CM-26, their original target, was a big letdown. It took a while to realize why.

The first few hours were the enjoyable confusion of a new home. The apprentices were assigned living quarters—huge, after the cramped cabins of the *Vantage*—then left free to roam the interior, alone or in groups, and get used to the layout.

Rick was on the same corridor as Gladys de Witt, Lafe Eklund, Polly Quint, and Goggles Landau. He was annoyed that he had not been placed with people he knew well, until he realized that was surely intentional. Turkey Gossage and Barney French had one thing in common: they both insisted that you had to be able to get along with absolutely anyone and learn to work together.

The five apprentices set out as a group to ramble the corridors and tunnels of the mining facility. Rick noted where Alice's cabin was located, though it was probably useless information; she always insisted that she come to him. She was right next door to Deedee Mao, which made Rick feel a bit uncomfortable.

The corridors that led deeper into the interior all ended with flashing lights and warning signs: DO NOT PROCEED BEYOND THIS POINT. MINING OPERATIONS IN PROGRESS.

The five retreated, somewhat irritated. "I thought mining operations were specifically what we were here to learn," Polly Quint grumbled. She was a tall, graceful seventeen-year-old, with an oddly large vocabulary and a flashing smile that at the moment was noticeably absent. "And what type of mining operations are being denied to us, anyway?"

They could hear along the forbidden tunnel the near-continuous rumble of explosions.

"Not what we saw on CM-31, that's for sure," said Gladys de Witt. "There's something odd going on here."

Rick agreed. During their approach to CM-26 he had caught a glimpse of an irregular chunk of rock, beside it the familiar gleam of a cylinder big enough to enclose it. But what they had just seen—or rather heard—suggested a traditional mine using ore blasting and excavation equipment.

The mystery remained as they headed in the opposite direction, up toward the outer layers of the mining station. It was compounded when they came to the topmost level and looked out through the transparent bubble of an observation port.

"It's *tiny*," Goggles Landau protested. "Look at the ship next to it!"

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They again had a view of the asteroid and cylinder that Rick had seen during final approach. At that time there was no way of judging size, and Rick had assumed that he was looking at something on the same massive scale as the ruined facility of CM-31. Now a maintenance module was floating in space next to the cylinder, and Rick could see that Goggles was right. Instead of the kilometer-plus length and width of CM-31, this cylinder was no more than forty meters in any dimension. The rock next to it was smaller yet, more like a large boulder than a substantial planetoid.

"That's not a mining facility," said Lafe Eklund at last. He was one of the quiet apprentices who rarely said anything, but now he sounded exasperated. "Look at that thing! It's nothing but a *toy*."

No one disagreed. Perplexed, they made their way back to the general living accommodation and ran into two other exploring parties. They had all experienced similar frustrations, of regions denied to them without explanation or mining facilities scaled down to the point where they appeared ludicrous. Without anyone suggesting it, they found themselves moving together to the main dining area.

Chick Teazle, as usual, took the lead. "I think we can all guess what's happening," he said. "So far as they are concerned, it's business as usual. We're back in the playpen, and we'll get pushed through the next stage of training as though we're still babies. But we're not."

There was a mutter of agreement.

"What happened at CM-31 changed everything," Chick continued. "They still want to treat us as Level Three apprentices, but we showed that we are ready to operate at Level Five—the highest level. We've grown up faster than anyone expected. They need to recognize that fact."

"How do we make them?" Alice Klein had been in a fourth group that had just entered the dining area and added itself to the discussion. "It's easy to *say* how Vanguard ought to think of us, but how do you persuade them?"

As usual, Alice had quietly placed her finger on the key question. There was a long pause, while everyone stared around at everyone else. Rick tried to catch Alice's eye, but she looked right through him.

"Only one way," said Chick Teazle at last. "Barney French is in charge of us. We have to tell her, all of us."

"*All* of us?" Vido repeated. He sounded as skeptical as Rick felt. "Forget it. You know what she says about committee decisions."

Barney had told them often enough: "Work in ones, work in twos, even work in threes. But *don't* form a committee, or you'll never get anything done. A committee is a dead-end street where ideas are lured and quietly strangled."

"All right, not all of us," Chick said defensively. "Not a committee, a deputation. Four people, representing everybody. Who'll volunteer?"

"You will," said Goggles Landau, and everyone laughed.

"I guess I have to, if I suggest it." Chick grimaced. "Who else?"

There was another long pause. "I nominate Rick Luban," Gladys de Witt

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said at last, while Rick stared at her in surprise. "He's one of Barney's pets, you can tell by the way she talks about him."

"Hey!" But Rick's outrage was lost in the buzz of general agreement.

"That's two," said Chick.

"Wait a minute! You said *volunteer!*"

"You've been volunteered." And before Rick could speak again, Chick went on. "Need two more. Who else? Vido Valdez, will you do it?"

"Hold on," Polly Quint said before Vido could reply. "I have nothing at all against Valdez, but you need balance. Better have two of the quartet females."

"Agreed." Vido grinned at her. "Thanks, Polly. Accepted, everyone?"

"Me? I never said *me!*"

But Chick was already looking around the group. "So it's agreed on Polly. Just one more. Gladys?"

"Bad choice. Barney says I complain all the time." Gladys stared around the room. "You need somebody who never bitches. How about Deedee? Will you? You know Barney thinks you walk on water."

"She does not!" But Deedee bit her lip, then slowly nodded. "All right. If you want me to."

"Which makes four. Good." Chick Teazle clapped his hands together briskly. "So there's only one other question: when?"

"Now," chorused a dozen voices.

"I was afraid you'd say that. Rick, Polly, Deedee?" Chick looked to each of them in turn. "All right with you? Then let's get it over with." He started for the door.

"Give 'em hell, guys," Skip Chung shouted after them as they left.

Brave words, but Rick felt the steam going out of him as he approached Barney's office.

She was in. He had rather hoped she would be somewhere else. She greeted them with a raised eyebrow, seated them on uncomfortable chairs made of bare metal struts and mesh, and listened in silence while Chick, with prompting from the other three, explained why they were there.

"I see," she said when he finished. "Level Five." She walked over to the inner door to her office and disappeared through it.

Polly and Deedee looked at each other. "Bad news," Deedee mouthed, and Polly nodded.

"Why?" Rick had seen the exchange.

"Can't you tell?" Deedee was whispering. "She's really angry."

"Or upset."

"Or both."

They were talking only to each other. Before Rick could ask how they knew, Barney was back. She was holding two polished metal cylinders about two feet long. One was thin, the other fat.

"So you're not happy," she said. Rick could see it now, there was a twisted look to the always-asymmetrical face that was new and frightening. "So you don't want to be treated as trainees anymore."

Trainees, not apprentices? They had been demoted, but no one was going to correct her.

"Well," Barney went on, "I have a question for all of you. What job do

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you expect to get when all your training is over?"

The four looked at each other. "Mining engineer?" said Chick Teazle at last.

"Mining engineer." Barney French nodded. "Do you know why you say that? Well, I do. You say it, you overgrown ape, because it's the only goddamn job any of you can imagine. So let me tell you something about Vanguard Mining. Maybe one person in a hundred makes mining engineer. Before you aspire to that, you have to be a real hotshot—you have to know math, and mechanics, and physics, and metallurgy, and engineering. Most people don't make it. I didn't make it, and I bust my guts trying. Do you think any of you will make it?"

There was a dead silence.

"Well, it's not my job to tell you that you won't. In fact, it's usually my job to tell you that you *can*. But right now you're a million miles away from competence." Barney tossed a sheet of paper across to Chick Teazle. "Read that, and tell me what it says."

He stared at it and shook his head. "I can't. I mean, I can read the words, most of 'em. But it's full of big equations."

"Damn right it is." Barney's face was growing redder. "Those are the equations of motion that describe the stability of a right circular cylinder under forced rotation, with off-axis disturbing forces. In other words, they describe a mining facility like CM-31. Unless you can read that, and maybe write something like it yourself, you'll never make a top-flight mining engineer. And if you do, you won't be getting an easy job. Better men than you'll ever be—and better women—have given their lives for that research." She glared at them, and her voice rose. "You think you're ready for Level Five, do you? You don't know what Level Five means. It means brains and dedication and endless hard work. It means devotion to duty, and sometimes it means sacrifice. The best engineer I ever met, Rusty Keck, was killed in the blowup of CM-31."

"I was there when he died," Deedee said in a very small voice.

It halted the outburst. Barney stared at her. "So you were," she said at last. "That makes me surprised that you are here."

She put the two cylinders down on her desk, stood up, and left the room again. This time she was gone for more than five minutes, while her visitors sat and asked each other in hushed tones if the meeting was over and they were supposed to leave.

When she returned her face was unreadable. She picked up the two cylinders from her desk as though they weighed a ton each. "The episode at CM-31 gave you a false idea of your own status," she said quietly. "You behaved well, and for an hour or two you did act at Level Five. But in terms of real training, you're still Level Three beginners. Can you tell me why one of these cylinders is stable when it's rotating about its main axis, and the other one isn't? No, you can't. Can you tell me how the stability changes, as the mass distribution changes from being mostly on the central axis to being near the outer curved surface? Again, you can't. But you will know those things,

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before you leave here, because we'll have done a dozen practical experiments with the centrifuge mining test facility that's waiting outside this station. You'll know what happens in practice. You'll also be able to *calculate* it, so you don't have to do expensive physical tests before you reach the final design stage. You'll know and do all these things, or your future jobs in Vanguard Mining will be cleaning toilets and recycling sewage. If you're lucky."

She sighed, and tossed one cylinder to Rick and the other to Deedee. "Take these and think about them. I should never have told you that you did well. And I ought not to have lost control of myself. I hope you'll forget that. I'm going to forget what you said to me. So far as I'm concerned, you never came here, and you never complained about anything. Now get out—before you make me real mad."

She ushered them out. In the corridor, well away from Barney's office, Chick stopped. "We-e-ll," he said. "Well . . . well . . . I guess . . . shit."

"The *mot juste*." Polly Quint tried to laugh, and produced only an ugly snort. "My English teacher told me—before he decided that he was more interested in getting into my pants than into my head—that cussing is the sign of an inferior intellect and an inadequate vocabulary. But in certain circumstances, he said, it fulfills a vital function. I guess this is one."

"But what are we going to tell the others? They'll be waiting for us back there, wanting to know how we did."

"We?" Polly shrugged. "It's not we, Chick. You are our chosen spokesman and chief representative. What are you proposing to tell them?"

To that question, for one of the few times in his life, Chick Teazle had no ready answer. ■

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Past Imperative, Dave Duncan, AvoNova, $22, 445 pp. (ISBN: 0-688-14361-X).
Vital Dust: Life as a Cosmic Imperative, Christian de Duve, Basic Books, $25, 362 + xxii pp. (ISBN: 0-465-09044-3).
Harlan Ellison Reads Paladin of the Lost Hour, Harlan Ellison, Harlan Ellison Recording Collection (P. O. Box 55548, Sherman Oaks, CA 91413), $15 + $2 s&h ($2.50 Canada, $4 overseas).

At the time of Ian McDonald's first novel, I suggested that he was "a master for a new generation of SF." Since then, his work has been quite marvelous and varied enough to make one think he well deserved the label. Indeed, when I reviewed his *Terminal Cafe* last August, I called it a "feast of inventive genius."

He hasn't lost it, folks. His latest, **Evolution's Shore**, is another such feast, flawed only by a certain hovering ambivalence about whether it is a novel of disaster or promise. McDonald clearly favors the latter, for he fails to let those aspects of society most invested in the status quo live up to their perception of events as catastrophic. This failure gives the novel a certain air of irreality quite aside from anything that follows from McDonald's fertile imagination.

Does McDonald need to take one more step, to become utterly convincing in every aspect of his tales, before we say he is certainly—not just apparently or possibly—a "master"? Probably not, for if we think of undisputed masters such as Heinlein or Asimov, they were by no means utterly convincing.

So—*Evolution's Shore*. It opens in Ireland, where young Gaby McAslan is contemplating her future. The boy? Or the career, meaning telejournalism school? A sign, please, she asks of the fates, and Lo! as her father is showing her Saturn's moon Iapetus and its mysterious darkening, the news reveals that Saturn's moon Hyperion has just vanished.

So—school. By the time she has a job with SkyNet, strange canisters reminiscent of Wells's *War of the Worlds* have landed here and there on Earth and seeded an alien ecosystem,

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named the Chaga after the people it displaced from the Kilimanjaro neighborhood. The Chaga expands at fifty meters per day, over eleven miles per year. It shows no sign of stopping, and in its realm Earthly life is replaced by strange and wonderful constructions or growths or . . . God alone knows what, except that UN scientists have figured out that Chaga chemistry is based on buckminsterfullerenes (buckyballs) and acts like SF nightmares of nanotech gone berserk. The world is doomed; the Chaga will eat it all in due time; and you would expect everyone with any sense of reality at all to be screaming, "MEEMIE!! MEEMIE!!"

Well, a few are. When Gaby reaches Africa, she meets some of them. But most people seem to be taking it in stride, much as she does herself—it is the star to which she plans to hitch her career. It is opportunity, and she—surely like most humans—is an opportunist.

She's an effective opportunist, too. She wastes no time in making connections and coming up with good stories, such as the one on Peter Werther, who died in the Chaga, was revived and absorbed and modified, and who has now emerged to reveal that the Chaga has been here before. The publicity she gives him only results in a UN raid and his disappearance, for the UN is desperately afraid of Chaga contamination, but it doesn't keep her from seizing opportunities.

One of those opportunities leads her to hack a friend's database and learn that Chaga contamination may not be all bad, for it can extend the lives of those who suffer from a kind of super-AIDS. In due course, she sneaks into the Chaga herself and learns a little more about modifications. On her return, she too disappears. Fortunately, she is by then prominent enough for that to be newsworthy. Protests pry her loose, and with her a host of UN secrets.

How much should I reveal? Gaby is a darlin' girl with opportunistically rubber ethics, a gift for making friends, and a mouth for destroying her own happiness. McDonald is very good at characterization. But let me focus more on the technical side: Think of the concept of "punctuated equilibrium," the idea that evolution proceeds by sudden bursts of variation after long periods during which nothing much happens. McDonald's conceit is that the bursts are due to alien "Evolvers" who send the Chaga periodically to transmute genomes, to explode established patterns into a host of variations (those modifications). Thus the title, and thus perhaps the ambivalence inherent in the book. Yes, the old order is falling, but a new one—*many* new ones!—will rise. This is pure enchantment to anyone with a sense of biological history, and—considering the way biotechnology has been developing in the last two decades—it is enough to make industry drool. Even when the Chaga is new, they find a number of useful gimmicks; they dream of more to come, bearing quite enough wealth and power to compensate for the loss of the old order.

McDonald has set up a very interesting situation, and it would be

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enough if that were all there was. But there is more. Part way through the course of the tale, Hyperion reappears, reconfigured into a disk that curls up into a cylinder and heads Earthward. The novel ends with Gaby's lover among those who are landing on this immense construct, finding airlocks, and entering to discover . . . what? McDonald only hints, which makes me think he must be planning a sequel.

I can hardly wait.

Robert T. Bakker has long been something of a paleontological "bad boy" for leaping from fossilized dinosaur tracks and nests to heretically speculative interpretations of saurian behavior. He is a Wyoming museum curator, an advisor to *Jurassic Park* special-effects artists, and the author of the nonfiction *Dinosaur Heresies*. Now he turns to fiction with **Raptor Red**.

This novel is actually something of a blend of fiction and nonfiction. The main character is a predatory dinosaur, a *Utahraptor*, much like the one in the movie. As the tale begins 120,000,000 years ago, she and her mate are attacking a brontosaurian *Astrodon*. Alas, her mate dies in the attack. Bereft, especially because she has now failed to fulfill her Darwinian imperative of producing chicks, she wanders until she encounters her temperamental sister and her chicks. She joins the family as a helpful aunt and eventually finds another prospective mate (whom her sister cannot stand). The enlarged pack proves formidable in hunting, but other, larger predators are becoming more numerous. The raptor pack moves up into the mountains, encountering as they travel dozens of other denizens of their era; in due time Raptor Red and her new mate fulfill their destiny.

What we have here is familiar, a classic natural history dramatization. And in this identity lies the nonfiction half of the novel. Bakker has his dinosaurs acting like birds in their courtships and rivalries and social connections. He gives them tick-birds, like those that pick parasites off rhinoceros hides. He gives them appetites, lusts, and rages, all modeled on what he knows of modern living things on the grounds that there is no alternative. A huge amount of his "natural history of the dinosaurs" is thus speculative, but it does make sense, and it does succeed in bringing the dinosaurian Cretaceous age to life.

The book has some problems. Bakker is no stylist, and his editors, despite the praise he lavishes on them, failed to detect or correct several spots where he seems to include extra drafts of the same paragraph, but if you love dinosaurs, this one's for you. And if you know someone—perhaps a kid—who loves dinosaurs, give them a copy.

Anne McCaffrey's **An Exchange of Gifts** is sweet, touching, warm, uncomplicated, deftly done, a charmer that should appeal to fans of McCaffrey and fairy-tale fantasy, and almost completely unchallenging to any reader's expectations. It is the tale of a young woman born to the nobility, burdened with high social expecta-

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tions, promised to a loathsome Baron, and blessed with the Gift of growing things. What choice does she have but to run away, a few homely items—a spoon, a bit of food, a flint, and a collection of seeds and seedlings—in her bag, to find a hovel and make her way as best she can, lonely but fulfilled. Of course, she has but the vaguest of notions of how to make a hovel a home.

But then Wisp shows up at the door. He is a slight youth, scarred and welted with the beatings he has fled. He knows how to sweep and mend and clear clogged chimneys, and soon they have a pleasant shelter from past abuses and foul weather. They come to depend on each other, indeed to feel considerable affection for each other, and when McCaffrey carefully drops the hints that Wisp is not what he seems, the acute reader wonders: Is he that very Baron, not loathsome after all, hidden beneath some magical disguise? When will the truth come out, and the blessed pair fall into each other's arms to live happily ever after?

Close, Dear Reader, but far enough off the mark to make me call this one *almost* completely unchallenging.

Dave Duncan continues to show a fertile imagination with his latest, **Past Imperative: Round One of the Great Game**. The basic idea is that there are parallel Earths accessible through various mystic portals, often associated with ancient holy sites such as Stonehenge. People who have crossed from one world to another have in their new home a sort of magical power that is strengthened by acts of worship. That is, they become gods. They also become immortal, grow bored, and succumb to whim and obsession. The Great Game is their version of politics or chess. We can and should pity their poor worshippers.

Yet perhaps not all these gods are so awful. Perhaps some are indeed devoted to protecting humanity and uplifting us to a utopia of dignity and freedom.

Let us, says Duncan, imagine that this is so. The former group comprise the Chamber (of Horrors). The latter is the Service, its image smelling vaguely of the British Colonial Service in the days when Empire was Duty and the white race, at least in its noble British form, bore the burden of all those little brown brothers with fortitude and grace.

Does that raise your suspicions? Meet Edward Exeter, a youth hot to rush off to World War I to fight the heathen Hun. He is the son of Cameron, a colonial administrator slaughtered by heathen Africans stirred up by missionaries, schooled to the Empire's Service himself, and full of honorable ideals. But one night at a friend's house, he and his friend raid the kitchen. There is hullabaloo, the friend is dead, Edward has a broken leg, and all doors are locked. There is no other suspect. Edward is clearly destined for the gallows.

Meanwhile, on the alternate Earth known as Nextdoor, meet a troupe of traveling actors. We learn that the youngest, the pre-teen Eleal, is mentioned in a prophecy that says she will come to a certain valley at a certain

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time and bathe and nurse the son of Kameron Kisster, who will become the Liberator, the slayer of Death. That time is fast approaching, and there are forces—the Chamber, of course—who wish to frustrate the prophecy and thus prevent the chain of events that must follow from it. Priests and priestesses of the gods conspire to imprison her in a temple, doomed to be a lifelong temple whore.

But she has friends—of the Service, of course—who bust her loose and set her on her destined path. So too does Edward, for he is saved from certain slaughter in his hospital bed by the timely arrival of an old friend, Mr. Oldcastle, who urges him to flee, bum leg or no, explains that Edward's father was one of them and was killed to block the prophecy, arranges for the instant healing of his leg, and in due time punts him across to Nextdoor.

Once Edward recovers from the physical and psychic shock of the transition, survives *turista*-squared, and learns the local language, he actually becomes something of a hero. But he does not want to stay on Nextdoor and live a prophesied destiny. He wants to go home and fight the Hun, even if he must flee new obligations of honor. The Service plays to this, and in the process it gives the reader a hint that it is as scheming, as manipulative, as ultimately heartless, as its foe.

The book's last few lines provide a hint of the next volume in the series, saying that Edward will indeed make it home but will find that even there he cannot escape the prophecy. This is perhaps enough to let us conclude that Duncan's theme here is the futility of attempting to evade destiny; one must willy-nilly embrace one's fate, for only there does honor lie.

Is Duncan successful? It's hard to say when a whole series still waits to be revealed, but his premise is intriguing, Nextdoor is an interesting world, his characters are easily up to the fantasy standard, and his plot moves nicely and holds the interest. Perhaps better, though many of his story's elements come from the genre's prop closet, he has given them a nice polish. This one is good, solid entertainment, with a promise of more.

One of the basic questions that has long fascinated SF writers and readers is the origin and history of life. Stories have played with the idea of "panspermia" (spores drifting in space), "directed panspermia" (aliens planting the seeds of life, deliberately or by accident), and creation, by humans or gods. They have looked at Earth's past and imagined parallels on other worlds. They have also wondered—fed by scientists who claim we are some sort of cosmic accident—just how inevitable has been the progression from self-reproducing protocell to self-determining human being. Stories have posited different chemistries, different anatomies, different kinds of intelligence.

The same questions are also—of course—of interest to scientists, who have originated most of the notions the SF writers and readers have played with and who have shown just as little unanimity in their theories.

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One of those scientists is Christian de Duve, a biochemist and molecular biologist who shared the 1974 Nobel Prize for biology or medicine. That was the same year that I wrote in these pages on the origin of life in the natural tendency of molecules to organize themselves in lifelike ways. Since then, de Duve has studied the same subject in great depth and come to a similar conclusion: "life is an obligatory manifestation of the combinatorial properties of matter" (p. xiv). The book in which he makes this statement is **Vital Dust: Life as a Cosmic Imperative**, which I urge you to read in conjunction with Daniel C. Dennett's *Darwin's Dangerous Idea: Evolution and the Meanings of Life*, which I reviewed two months ago.

Basing his arguments in the nature of chemistry and natural selection, de Duve goes even further: "From the perspective of determinism and constrained contingency that pervades the history of life as I have reconstructed it, life and mind emerge not as the results of freakish accidents, but as natural manifestations of matter, written into the fabric of the universe" (p. xviii). To those who argue for the dominance of chance and the sheer flukiness of the existence of humans, intelligence, and/or mind, he says that the role of chance has to be limited to the details, for "No two streams follow exactly the same course down a mountain, but all may end up in the same valley" (p. 85).

"[L]ife is almost bound to arise, in a molecular form not very different from its form on Earth, wherever physical conditions are similar to those that prevailed on our planet some four billion years ago. This conclusion seems to me inescapable. Those who claim that life is a highly improbable event, possibly unique, have not looked closely enough at the chemical realities underlying the origin of life. Life is either a reproducible, almost commonplace manifestation of matter, given certain conditions, or a miracle. Too many steps are involved to allow for something in between.

"If I am right, there are about as many living planets in the universe as there are planets capable of generating and sustaining life. . . . Trillions of biospheres coast through space on trillions of planets, channeling matter and energy into the creative fluxes of evolution. In whatever direction we turn our eyes when we look into the sky, there is life out there, somewhere. . . . The Earth is part, together with trillions of other Earth-like bodies, of a cosmic cloud of 'vital dust' that exists because the universe is what it is. Avoiding any mention of design, we may, in a purely factual sense, state that the universe is constructed in such a way that this multitude of life-bearing planets was bound to arise" (p. 292).

"[A] significant subset of existing biospheres have achieved intelligence, or are on the way to it. . . . According to the view I defend, it is in the nature of life to beget intelligence wherever and whenever conditions allow. . . . Conscious thought belongs to the cosmological picture, not as some freak epiphenomenon peculiar

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to our own biosphere, but as a fundamental manifestation of matter" (p. 297).

That is, he emerges from his survey of the history of life on Earth, from primordial ooze to humanity, with the expectation that the chemistry and thought-patterns of intelligent extraterrestrials seem likely to resemble our own. He even seems almost willing to say that intelligent ETs must have a physical form we could relate to—not necessarily humanoid, but with head and torso and limbs. The upshot is a Universe in which much of SF must seem not so strange after all.

On the other hand, de Duve gives short shrift indeed to some of the ideas that have fed SF. For instance, he has little sympathy for Teilhard de Chardin's noospheres and Omega Points, even though he does try hard to see in the Universe's tendency to life and intelligence a Universe with meaning.

What is that meaning? Contradicting Jacques Monod, de Duve insists that the Universe was and is pregnant with life, and the biosphere with man. "Thought . . . is a faculty whereby the universe can reflect upon itself, discover its own structure, and apprehend such immanent entities as truth, beauty, goodness, and love. Such is the meaning of the universe, as I see it" (p. 301).

Like Dennett, de Duve offers us an eloquent antidote to the fuzzy thinking that is so common in our world. Read it.

Harlan Ellison called the other day to ask whether I would be interested in seeing his CD, **Harlan Ellison Reads Paladin of the Lost Hour**. I said, "Sure, send it along," and in due time it showed up in the mail. I promptly stuck it in my computer's CD-ROM drive and listened (yes, folks, in case you had ever wondered, a computer CD-ROM drive will play audio CDs; you can listen while you work).

The decade-old "Paladin" story—Hugo winner, Nebula finalist, and also available in Ellison's collection, *Angry Candy*—involves two men, one old, one young, one black, one white. Both are visiting cemetery memories when muggers attack the old man. The young one intervenes, and the two become friends. Later, the old man reveals that he is the guardian of a treasure, a magical watch and a single hour whose passing will end the world. The young man, who insists that he has never been responsible for anything, much less the entire world, may be the next guardian. The upshot is moving and effective.

Ellison's patent anger and passion show in full measure in the print version, and with Ellison himself expressing voices and moods aloud, they show no less on the CD. Ellison does such a fine and expressive job of reading that it is hard to imagine anyone else in the role. He also gives you a sense of meeting Harlan the Storyteller in person. If you want to hear more of him, you can join the "Harlan Ellison Recording Collection" for $8, which gets you four issues of a newsletter plus "the privilege of obtaining new, never-before-released,

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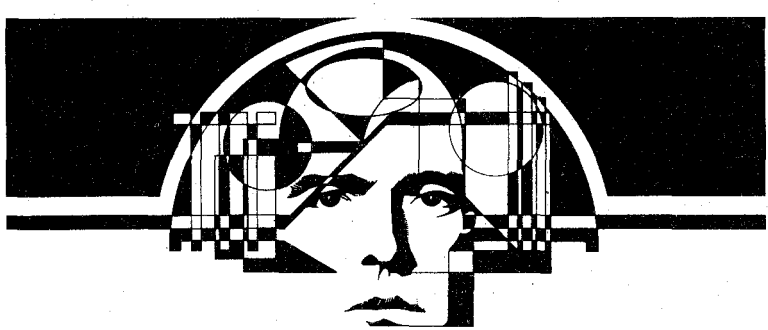
top-quality records, cassettes and CDs of Harlan Ellison reading his award-winning stories."

By the way, Harlan included several other items in the package as well. One was the 1994 book *Mindfields* (72 pp., $24.95 from Morpheus International, ISBN: 0-9623447-9-6), in which he wrote short, impressionistic fictions to accompany the strangely bizarre paintings of Jack Yerka. I found it a pleasure to peruse, especially the artwork, which does such things as give an antique car an alligator-like tail and clawed legs, as if it were a dinosaur of automotive technology.

Also in the package were five 1995 "graphic novel" offerings from Dark Horse Comics. *Harlan Ellison's Dream Corridor Special* ($4.95) says he gets his ideas from the "Dream Corridor," and offers several shorts to illustrate the point. The others were the four installments of the graphic adaptation of Ellison's famous "I Have No Mouth and I Must Scream" ($2.95 each). ■



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BRASS TACKS

Dear Mr. Schmidt,

I am somewhat confused. The name of your magazine says *Analog Science Fiction and Fact.*

In the August issue, the story "The Maltese Elephant" was neither science fiction nor fact. Although it was an interesting story, I cannot see where it had any place in *Analog.* If I wanted to read non-science detective stories, I would buy detective magazines.

I hope there will not be any more of this type of story in *Analog.* I have been reading science fiction since 1936, and *Analog* since it was first published. I have always found it to be a clean, interesting magazine. Please keep it that way. Thank you!

FRANK A. REED JR.

P.O. Box 275
Langlois, OR 97450

I'm sorry you didn't consider "The Maltese Elephant" science fiction. It actually is, though the speculative element is small: that small numbers of the Maltese elephant (which actually existed) survived to the present. Of course, its primary *emphasis was on neither the science fictional nor the detective aspect, but the parody; so it needed to be read primarily as a humor piece.*

Dear Stan,

This is just a short note to let you and Harry Turtledove know how much I enjoyed his recent story, "The Maltese Elephant." It's a worthy addition to the shelf which contains such other classics as "Red Planet Harvest," "The Jurassic Key," "The Requiem Curse," and "The Thin Bem." (Not to mention my favorite Parachronian Op story, "The Timeslip Knockover!") THANKS! to you and Harry for the opportunity to read his fine "off-trail" yarn.

MICHAEL D. TOMAN

S. Pasadena, CA

Dear Mr. Schmidt,

I enjoyed the article "Back to the Moon—At Last! The Clementine Solution" by Doug Beason in the August 1995 issue. I agree that we must find "faster, cheaper, better" ways to move back into space. One minor nitpik: I'm sure that Doug Beason and you both know better, but somehow the statement slipped in that Apollo 15 was our last manned visit to another planet. I'm sure if you let your mind drift back to December of 1972, you will remember Cernan and Schmitt at Taurus-Littrow, following a dazzling night take-off on the Apollo 17 mis-

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sion, our most recent (let's don't say "last") trip to the Moon.

CECIL ROSE

via the Internet

Oops! Indeed I do know better—I was there!

Dear Editors:

Doug Beason's "Back to the Moon—At Last! The Clementine Solution" (August 1995) provides an interesting overview of the development of the Clementine lunar probe and of the "skunk works" approach to aviation development.

Unfortunately, it then segues into what looks uncomfortably like a political endorsement for military funding increases (a perception some of *Analog*'s editorial staff must have shared, to judge by the disclaimer appended to the piece). In the process, it raises some interesting questions.

The examples given of governmental encouragement of exploration and technological development, for example, are *all* military. There's a paradox here I've noted before: many people who want to "get government out" of this field or that because of government's presumably innate inefficiency make a convenient exception for military efforts (and allied operations, such as intelligence—e.g., the CIA). Interestingly, Beason's views seem contrary to the idea often expressed in your pages that the federal government should get out of the space business altogether; I'd be curious to know how adherents to that view feel about this article.

There's a deeper issue involved as well. The fact is that most U.S. advances in science, technology and exploration which owe anything at all to the government do come from the military—because that's where the funding for R&D and exploration goes. (The same is true in Britain, helping to explain the Darwin example.)

Indeed, any massive national expenditure seems to have a better chance of passage if it can be given a military justification of some sort. One often hears, for instance, that it was not the New Deal but World War II which ended the Great Depression in America, and there's some truth to that—but a good part of the reason is that the government spent far more to build up the sinews of war than it was ever willing to authorize in the thirties for New Deal programs. After the war against the Axis, the Cold War kept government-funded research efforts focused on work with military applications. This reality gave us the NASA we know, a "civilian" agency stuffed with military officers and firmly tied to military and intelligence interests, for good and ill alike; a purely civilian agency, devoted only to space exploration, would never have been funded for Apollo-scale (or even Clementine-scale) efforts, and probably never will be. These days, the hottest big space effort is BMD, a military program conceived to defend against (or, possibly, support an attack on) an adversary which no longer exists. What does that say about our values as a society?

I also foresee problems with applying "faster-cheaper-better" planning to *human* space exploration. It worked with Clementine because the probe

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was designed to be small—but it didn't carry human beings. Anything designed to do that has to be large, especially if it's also to carry even the most basic necessities for setting up, say, a lunar base. There are sure to be ways to cut costs without endangering mission success, but even so, sending humans back to the Moon and beyond will cost. It won't be a matter of just "scaling up" Clementine-style efforts, either—that's what I call the "Mothra fallacy." Building larger craft, and especially adding the capacity to sustain human crews, will mean an increase in complexity as well as size—and therefore, added costs.

We may be able to do it faster or cheaper this time, and certainly, with modern technology, better (if nobody decides to make the sorts of false economies that hurt the Shuttle)—but I wouldn't bet on all three. We just have to be prepared to convince Congress and the people that human space exploration is worth it.

ERIC B. LIPPS
328 Van Duzer Street
Staten Island, NY 10304

Dear Dr. Schmidt,

I can only agree with your editorial analysis in the August edition. There is much wisdom in your advocation for prudent use of technology, that is, only using it if it enables you to do something better. And better does not neccessarily mean quicker.

For many years I spent my leisure hours reading literature of the 19th and mid-20th century. I believed that I could find purer expressive use of the English language in literature at this period. One can only assume that to lessen the formidable undertaking of novel writing, many of the authors undertook a mental editing process which is possibly more rigorous than those of many of today's authors. Use of the word processor has made novels a much longer art-form.

As a supplement to regular mail I believe e-mail is a wonderful addition. I hope to take a course at a university in your country, submitting work by e-mail.

Thank you for pointing out to all readers the dangers of unaccountablity. We are often told about the marvels of electronic democracy. And in a sense these would be remarkable if pursued honestly and ethically. But imagine if a group of persons found a way of corrupting electronic votes. That could easily lead to dictatorship.

NORMAN FINLAY
via the Internet

Dear Dr. Schmidt,

About the "Anonymous Society" (August 1995):

I tend to consider e-mail as the modern version of telegrams and radiograms. The fact is, I could transmit a message and sign it KA8EPS or KOJ8021. That is anonymous unless you have a copy of the proper "call book." It is also dehumanizing. At one time "handles" were first names. The trouble is, there must be several million Jims in the U.S.A. People started using nicknames on the air almost as soon as they began using first names. I think they were trying to make telegraphy and telephone more like normal conversation.

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There is another point worth making. In this culture, males tend to do a lot of woofing and close friends frequently say things to each other that would bring strangers to blows. Owen Wister pointed that out in the *Virginian*. "When you call me that, smile." Some insults and threats are intended to establish a pecking order. I agree, people should be a little more careful about what they say on-line, but the politically correct seem to lack common sense.

JIM RITTER

Montrose, MI

Dear Dr. Schmidt,

Your editorial (August 1995) leads me to believe you don't use e-mail and therefore don't understand its use.

Point one: ". . . and a method that practically forces haste on you . . ." shows that you don't understand the use of off-line writing. A serious e-mail user does not create on the fly on-line, but retrieves the mail for more deliberate response and uploading.

"People who spend much of their lives at keyboards connected to modems . . ." understand that quality of communication is crucial to making sure that what one says is heeded.

Point two: "It's too easy to 'flame' online: . . ." is for the puerile punks who feel that anything not to their liking deserves a massive retaliation without content. Who cares about this type of user?

Point three: ". . . Mr. Hart's observation that business people today will often use e-mail preferentially because it makes it so easy to say things without later having to own up to them." This is so absurd as to be ludicrous. How can you put something in e-mail and think that it will never come back to bite you! A poorly thought out missive will be saved by the recipient on the chance that it can be used against the sender at some later time. Just because it is not on paper does not insure that it will have a short life and be forgotten! And anonymity is reaaally difficult on a system that attaches your name to every missive whether you want it or not.

My main complaint with e-mail is its lack of emotional content, and lack of clues to the sender's intent. A poor choice of words can make e-mail come through with a very curt, abrasive tone when none is intended. Hence the use of on-line clues such as <G> to help.

Sorry for the logorrhea! I do enjoy your editorials. This is the first one I have written about, though not the first one with which I strongly disagreed.

RICHARD SIMMERS

Honolulu, HI

I do use e-mail, when and only when it seems the best and most convenient tool for the job. And I get *a* lot *of it. You describe how "serious e-mail users" operate, which is fine, but not everyone fits that description. I've seen plenty of direct evidence that the problems I mentioned* are *problems.*

Dear Dr. Schmidt,

Well, it seems that science fiction

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has predicted real life once more. Some time ago, I recall reading a story in *Analog* about a robotic process that kept destroying one of its four arms ("Human Factors" by Lou Grinzo, February 1992). It was discovered (as I recall) that the program realized that three arms worked better than four for the particular operation it was doing, but part of the programming required all four arms to be in on the process. I read now in the Information press that various companies (John Deere, among them) are using such "genetic algorithms" to find the best way to manufacture some of its tractors. My hearty congratulations to the prescient author! As always, keep up the good work! I know the thoughts expressed here are my own because no one else would claim them!

DON HARRINGTON

Seattle, WA ■

JOHN BRUNNER
1934-1995

John Brunner, a writer well known for his prolific production, experiments in a wide variety of styles, and social consciousness expressed both in his writing and through support of several political causes, died August 25, 1995, after suffering a stroke at the World Science Fiction Convention in Glasgow, Scotland. His total output included nearly 100 books and a prodigious number of shorter pieces, both prose and poetry. Some of his novels, notably *Stand on Zanzibar, The Jagged Orbit, The Sheep Look Up,* and *The Shockwave Rider,* are still considered milestones in the field.

He sold his first novel at the age of 17 and used the proceeds to buy his first typewriter. His first major magazine sale was to this magazine, then called *Astounding:* "Thou Good and Faithful," was the March 1953 cover story, under the pseudonym John Loxmith. Ironically, the health problems that contributed strongly to his early interest in reading and writing much later caused his productivity to fall off, though he continued to produce stories right up to his death. In recent years, after too long an absence, he had again begun making occasional appearances in our pages, and we deeply regret that there will be no more.

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UPCOMING EVENTS Anthony Lewis

5–8 April

EVOLUTION (47th British National SF Convention) at Radisson Edwardian Hotel, Heathrow Airport, London, England, U.K. Guests of Honour—Vernor Vinge, Colin Greenland; Artist Guest of Honour—Bryan Talbot; Science & Fan Guest of Honour—Jack Cohen; Fan Guests of Honour—Paul Kincaid & Maureen Speller. Registration: £13 supporting, £24 attending. Info: Evolution, c/o 13 Lindfield Gardens, Hampstead, London NW3 6PX, England, U.K. E-mail: bmh@ee.ic.ac.uk, b.hardcastle@imperial.ac.uk

12–14 April

I-CON XV (Long Island area SF conference) at Holiday Inn & SUNY Stony Brook, N.Y. Guests include George Alec Effinger, Alan Dean Foster, Damon Knight, Kate Wilhelm, Barry N. Malzberg, etc. Registration: $24 until 28 February, $28 at the door. Info: Icon SF, Inc., Box 550, Stony Brook, NY 11790. (516) 632-6045, fax (516) 632-6355. E-mail: icon@ic.sunysb.edu WWW http://www.I-Con.com

19–21 April

CON-TROLL (Houston area SF conference) at Ramada Astrodome, Houston, TX. Guests of Honor—Harry Harrison & C. J. Cherryh; Artist Guest of Honor—Mary Hanson-Roberts; Special Guests—Lynn Abbey, Jane S. Fancher. Registration: $25 until 15 March, $35 at the door. Info: Con-Troll Conventions, Inc., Box 740969-1025, Houston, TX 77274. (713) 895-9202.

26–28 April

DEEPSOUTHCON '96 (Deep South SF conference at Best Western, Jekyll Island, GA. Guests—Harry Turtledove, Peggy Ranson, Joe Siclari, Edie Stern, Jack C. Haldeman II, and Jack McDevitt. Registration: $25 until 31 March, $30 thereafter. Info: Deepsouthcon '96, Box 1271, Brunswick, GA 31521. (912) 638-1486. E-mail: 74076.3703@CompuServe.com

29 August–2 September

L.A.CON III (54th World Science Fiction Convention) at Convention Center, Hilton, and Marriott Hotels, Anaheim, CA. Guest of Honor—James White; Media Guest of Honor—Roger Corman; Fan Guests of Honor—Takumi and Sachiko Shibano; Special Guest—Elsie Wollheim; TM—Connie Willis. Registration: $110 until 31 December, then higher. Child-in-tow (3-12): $35, infants are free; Supporting: $30. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Join now and get to nominate and vote for the Hugo Awards and the John W. Campbell Award for Best New Writer. Info: L.A.Con III, c/o/ SCIFI, Box 8442, Van Nuys, CA 91409. E-mail: lacon3info@netcom.com

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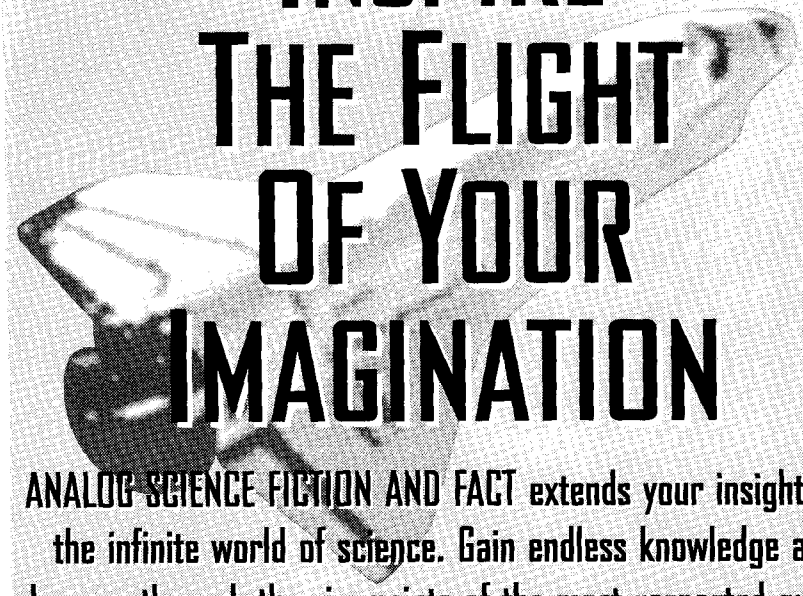

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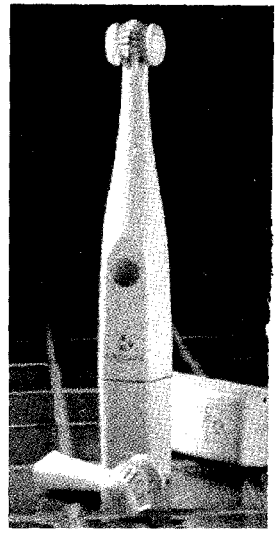

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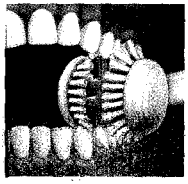

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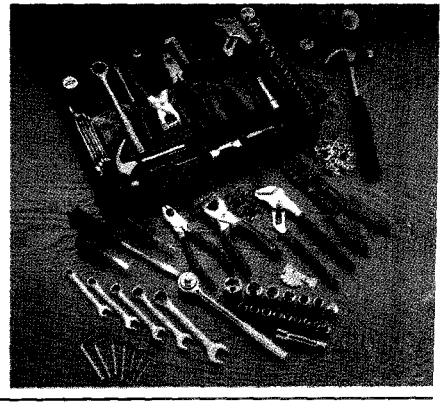

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